

Prepared in cooperation with the U.S. Army Joint Readiness Training Center and the Fort Polk Military Reservation

Aquatic-Life Criteria Compared to Concentrations of Cadmium, Copper, Lead, and Zinc in Streams near Fort Polk Military Reservation, Louisiana, December 2015–August 2016



Scientific Investigations Report 2021–5101

Cover photographs (sites near the Fort Polk Military Reservation):

Background, Right bank at site 2 near the Peason Ridge training area.

Upper left, Automatic water sampler at site 2 near the Peason Ridge training area during high stage.

Bottom left, Streambed-sediment sampling at site 1 near the Peason Ridge training area.

Bottom right, Monitoring well installation using direct-push drilling at site 4 near the Main Post.

(Photographs by Dennis Jeffrey and Roland W. Tollett, U.S. Geological Survey.)

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By Roland W. Tollett

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U.S. Geological Survey**

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m ²)
square mile (mi ²)	2.590	square kilometer (km ²)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
 $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
 $^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$.

Datum

Vertical coordinate information in this report is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information in this report is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g}/\text{L}$).

Concentrations of chemical constituents in streambed sediment are given in milligrams per kilograms.

Symbols

>, greater than

<, less than

\geq , greater than or equal to

\leq , less than or equal to

Abbreviations

µm	micrometer
BML	biotic ligand model
CCC	criterion continuous concentration
CMC	criterion maximum concentration
DO	dissolved oxygen
DOC	dissolved organic carbon
E	estimated concentration
EPA	U.S. Environmental Protection Agency
JRTC	Joint Readiness Training Center
LDEQ	Louisiana Department of Environmental Quality
MCL	maximum contaminant level
mL	milliliter
NTRU	nephelometric turbidity ratio unit
RPD	relative percent difference
USGS	U.S. Geological Survey

Aquatic-Life Criteria Compared to Concentrations of Cadmium, Copper, Lead, and Zinc in Streams near Fort Polk Military Reservation, Louisiana, December 2015–August 2016

By Roland W. Tollett

Abstract

The primary focus of this study was to document cadmium, copper, lead, and zinc concentrations in selected streams near the U.S. Army Joint Readiness Training Center (JRTC) and Fort Polk Military Reservation and to compare those values to Federal and State aquatic-life criteria guidelines. The acute aquatic-life criteria used for this study are as follows: the U.S. Environmental Protection Agency (EPA) aquatic-life criterion maximum concentration (CMC) based on hardness, the EPA CMC for copper based on the biotic ligand model (BLM), and the Louisiana Department of Environmental Quality (LDEQ) acute aquatic-life criteria based on hardness. The chronic aquatic-life criteria used for this study are as follows: the EPA aquatic-life criterion continuous concentration (CCC) based on hardness, the EPA CCC for copper based on the BLM, and the LDEQ chronic aquatic-life criteria based on hardness.

Cadmium was detected in one stream-water sample collected near the Peason Ridge training area, hereinafter referred to as Peason Ridge, and one stream-water sample collected near North and South Fort Polk, hereinafter referred to as the Main Post. A cadmium concentration of an estimated (E) 0.48 microgram per liter ($\mu\text{g/L}$) in a stream-water sample collected during high stage near Peason Ridge exceeded the EPA CMC of 0.10 $\mu\text{g/L}$. A second cadmium concentration of E0.33 $\mu\text{g/L}$ in a stream-water sample collected during low stage exceeded the EPA CMC of 0.22 $\mu\text{g/L}$, and a 4-day average cadmium concentration of E0.16 $\mu\text{g/L}$ exceeded the EPA CCC of 0.14 $\mu\text{g/L}$.

Copper was detected in 34 stream-water samples collected near Peason Ridge and 22 stream-water samples collected near the Main Post. The EPA acute criteria for copper were exceeded 17 times in stream-water samples collected near Peason Ridge and 19 times in stream-water samples collected near the Main Post. The EPA chronic criteria for copper were exceeded five times in stream-water samples collected near Peason Ridge and seven times in stream-water samples collected near the Main Post.

Lead was detected in 31 stream-water samples collected near Peason Ridge and 16 stream-water samples collected near the Main Post. A concentration of 6.0 $\mu\text{g/L}$ in a stream-water sample collected during high stage at site 2 near Peason Ridge exceeded the EPA CMC of 5.5 $\mu\text{g/L}$, and a concentration of 4.1 $\mu\text{g/L}$ in a stream-water sample collected during high stage at site 4 near the Main Post exceeded the EPA CMC of 2.9 $\mu\text{g/L}$. The EPA chronic criteria for lead were exceeded nine times in stream-water samples collected near Peason Ridge and three times in stream-water samples collected near the Main Post. The LDEQ chronic criteria were exceeded two times in stream-water samples near Peason Ridge and none near the Main Post.

Zinc was detected in 35 stream-water samples collected near Peason Ridge and 17 stream-water samples collected near the Main Post. A concentration of 100 $\mu\text{g/L}$ in a stream-water sample collected at site 3 near Peason Ridge exceeded the EPA CMC of 8.9 $\mu\text{g/L}$ and the LDEQ acute aquatic-life criteria of 36 $\mu\text{g/L}$. One 4-day average zinc concentration, E28 $\mu\text{g/L}$ for stream-water samples collected from site 3 near Peason Ridge, exceeded the EPA CCC of 8.2 $\mu\text{g/L}$; however, no concentrations of zinc exceeded the LDEQ chronic aquatic-life criteria near Peason Ridge or the Main Post.

The presence of copper, lead, and zinc at concentrations above the calculated acute or chronic aquatic-life criteria for some stream-water samples collected in relatively pristine streams near Peason Ridge and the Main Post indicates that these waters are susceptible to elevated trace element concentrations likely because of low ionic strength and hardness.

Introduction

Creating sustainable military ranges by minimally affecting natural resources, namely stream water, groundwater, streambed sediment, and soils, is a focus of the U.S. Army Joint Readiness Training Center (JRTC) and Fort Polk Military Reservation, hereinafter referred to as the Reservation (U.S. Army, Fort Polk Environmental Resources Management

Division, 2021). Reports published by the JRTC and Fort Polk Operational Range Assessment Program (Phase I, performed in 2009; Phase II, performed in 2013) noted that concentrations of selected trace elements (lead and copper) exceeded the Louisiana Department of Environmental Quality (LDEQ) aquatic-life criteria at some locations in streams draining the Reservation. Federal and Louisiana aquatic-life criteria for cadmium, copper, lead, and zinc are calculated based on the hardness values for freshwater streams (U.S. Environmental Protection Agency [EPA], 2002; LDEQ, 2015). Historical data indicate that hardness, total dissolved solids, pH, and specific conductance values typically were low in the streams draining the Reservation (Tollett and Fendick, 1998 and 2007; Tollett and others, 2002; Bryan and others, 2007). As a result of low-ionic-strength water in streams at Fort Polk, exceedances of hardness-based aquatic-life criteria for cadmium, copper, lead, and zinc could be misleading because these criteria are expected to be extremely low.

From 2015 to 2016, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army JRTC and the Fort Polk Military Reservation, measured or analyzed concentrations of field parameters, major inorganic ions, selected trace elements, dissolved organic carbon, and nutrients in stream water and groundwater and major inorganic ions, selected trace elements, and grain-size distribution in streambed sediment and soil at five sites located in watersheds outside of, but near, the Reservation boundaries (fig. 1). These background concentrations can be used to compare with concentrations documented on the Reservation to help assess whether military training exercises have affected the quality of water, streambed sediment, and soils on the Reservation.

Purpose and Scope

This report describes the field parameters and chemical characteristics of stream water in watersheds near the Reservation. Field and laboratory methods used in the collection of water-quality samples are included. The primary focus of this report is to document trace element concentrations of cadmium, copper, lead, and zinc in selected streams near the Reservation and compare those concentrations to the calculated Federal and State aquatic-life criteria. The data presented in the report are intended to document background concentrations of selected constituents in streams and watersheds located outside of, but near, Reservation boundaries and to assist the U.S. Army in evaluating concentrations of these constituents documented in watersheds on

the Reservation. All water-quality data are publicly available from the USGS National Water Information System database (USGS, 2020). Data, including stream-water, groundwater, streambed-sediment, and soil-sample data, collected during with this study are available in the associated data release at <https://doi.org/10.5066/F74M93FJ> (Heal and Tollett, 2020).

Description of the Study Area

The study area includes parts of Natchitoches, Vernon, and Rapides Parishes in west-central Louisiana (fig. 1). The physical characteristics of the study area, including topography, basin slope and shape, area, and geology, along with climate and land use, influence the water quality of streams and groundwater within watersheds. The streams sampled in this report are classified as first- and second-order streams that drain hilly, densely forested, piney uplands and are located near the headwaters of the Calcasieu River. The land use of the study area is primarily forest (table 1) (Homer and others, 2015). The watersheds are characterized by loamy soils, high runoff, and rapid changes in stream stage during heavy rainfall-runoff events. Drainage basins ranged from about 200 to 450 feet (ft) above National Geodetic Vertical Datum of 1929 (NGVD 29) and contain slopes that are prone to soil erosion (Muse, 2002). The climate in west-central Louisiana is humid subtropical, with an average 30-year normal (1981–2010) rainfall and temperature of 58 inches and 18.7 degrees Celsius, respectively (Arguez and others, 2010).

Interbedded clays, silts, sands, and gravels crop out in the study area and range in age from Miocene to Holocene (fig. 2). The general dip of these beds is southerly to southeasterly towards the Gulf of Mexico, and the strike generally runs east to west. The stratigraphic unit that crops out and underlies the Peason Ridge training area, hereinafter referred to as Peason Ridge, and surrounding area is the Carnahan Bayou Member of the Fleming Formation of Miocene age, which includes the Carnahan Bayou aquifer (Welch, 1942; McWreath and Smoot, 1989; McCulloh and Heinrich, 1999). The stratigraphic units that crop out and underlie North and South Fort Polk, hereinafter referred to as the Main Post, and surrounding area are the Blounts Creek Member of the Fleming Formation of Pliocene to Miocene age, which includes the Evangeline aquifer, and unnamed Pleistocene deposits, which include the Chicot aquifer system (Rogers and Calandro, 1965; McCulloh and Heinrich, 1999).

Table 1. Percentages of land-use type for three stream-water sites located near the Peason Ridge training area and two stream-water sites located near the Main Post, Fort Polk Military Reservation, Louisiana (Homer and others, 2015).

Land-use type	Sites near the Peason Ridge training area			Sites near the Main Post	
	Site 1	Site 2	Site 3	Site 4	Site 5
Open water	---	---	---	---	0.03
Developed, open space	2.3	2.6	3.9	1.6	2.5
Developed, low intensity	0.65	0.19	1.3	---	2.9
Barren land	---	---	0.06	---	0.20
Deciduous forest	3.5	1.6	8.2	6.9	---
Evergreen forest	80	85	52	61	45
Mixed forest	0.98	1.8	12	12	2.2
Shrubland/Scrubland	11	8.5	22	3.6	41
Herbaceous	---	0.08	0.31	---	3.5
Woody Wetlands	0.55	0.21	0.44	15	2.8
Emergent woody wetlands	---	---	---	0.07	---

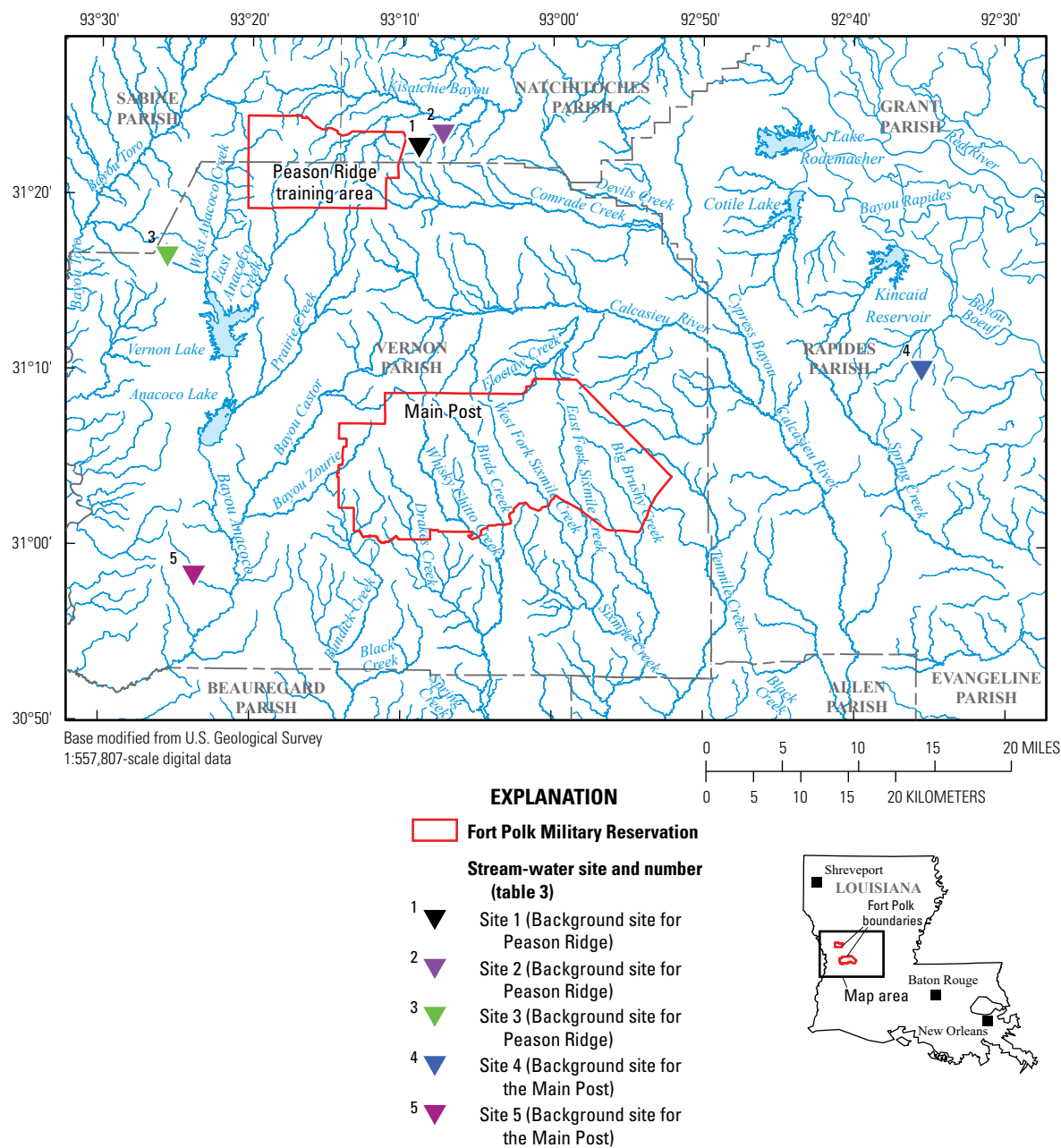


Figure 1. Locations of three sites near the Peason Ridge training area and two sites near the Main Post where stream-water, streambed-sediment, groundwater, and soil samples were collected, Fort Polk Military Reservation, Louisiana, December 2015–August 2016 (Heal and Tollett, 2020).

Methods

Methods used to collect and analyze water-quality samples are listed in table 2. Stream-water samples were analyzed for the field parameters of temperature, pH, turbidity, specific conductance, dissolved oxygen, and alkalinity; major inorganic ions; selected trace elements; organic carbon; and selected nutrients. A complete list of properties and constituents is presented in appendix 1. Parts-per-billion protocols documented in the National Field Manual for the Collection

of Water-Quality Data (USGS, variously dated) were used for cleaning equipment and field-sampling techniques. All analyses were conducted by RTI Laboratories in Livonia, Michigan. Water-quality, streambed-sediment, and soil data are stored in the USGS National Water Information System and are available through links on the USGS Water Data for the Nation website (USGS, 2020) and the accompanying data release (Heal and Tollett, 2020). Grain-size analyses and geographic information system metadata are available in the related data release (Heal and Tollett, 2020).

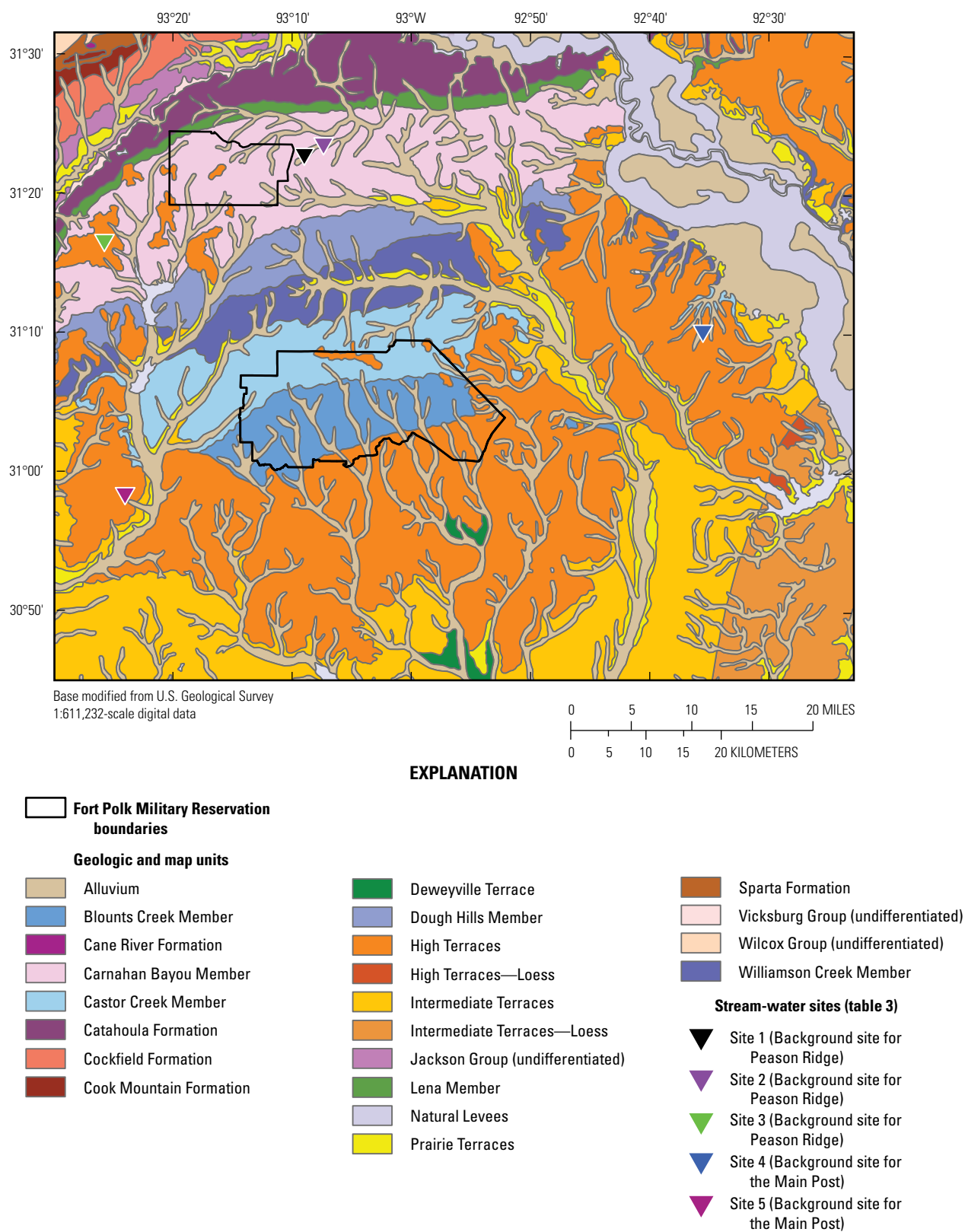


Figure 2. Geologic units and locations of three sites near the Peason Ridge training area and 2 sites near the Main Post where stream-water samples were collected, Fort Polk Military Reservation, Louisiana, December 2015–August 2016. Formation names and map units follow usage of the Louisiana Geological Survey (Snead and McCulloh, 1984).

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Table 2. Methods used to determine field parameters and selected chemical constituents in water at three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, Louisiana, December 2015–August 2016.

[USGS, U.S. Geological Survey; EPA, U.S. Environmental Protection Agency; N, nitrogen; P, phosphorous; LOI, loss on ignition]

USGS parameter description	Meter type or analytical method ¹	USGS parameter description	Meter type or analytical method ¹
Field parameters in water			
Dissolved oxygen	YSI® 6920	Turbidity	Hach® 2100P
pH	YSI® 6920	Alkalinity	Hach® 250A+
Specific conductance	YSI® 6920	Bicarbonate	Hach® 250A+
Temperature, water	YSI® 6920	Hardness (calculated)	Hem, 1985
Major inorganic ions in water			
Calcium	SW6020A	Potassium	SW6020A
Chloride	EPA 300.0	Sodium	SW6020A
Fluoride	EPA 300.0	Sulfate	EPA 300.0
Magnesium	SW6020A		
Trace elements in water			
Antimony	SW6020A	Lead	SW6020A
Arsenic	SW6020A	Magnesium	SW6020A
Bromide	EPA 300.0	Manganese	SW6020A
Cadmium	SW6020A	Mercury	SW7470A/SW7471B
Copper	SW6020A	Zinc	SW6020A
Iron	SW6020A		
Nutrients and dissolved organic carbon in water			
Nitrogen, nitrate as N	EPA 300.0	Orthophosphate, as P	EPA 300.0
Nitrogen, nitrite as N	EPA 300.0	Dissolved organic carbon	SM5310B

¹Descriptions and references for analytical methods are available on the National Environment Methods Index website (<https://www.nemi.gov/>).

Site Selection

Stream-water samples were collected from December 2015 through August 2016 at five sites located outside of, but near, the Reservation boundaries (table 3; fig. 1). These sites were positioned in watersheds that have the same geologic units (fig. 2) and similar watershed sizes as in the Peason Ridge and the Main Post (figs. 3–6). A stream reach was identified for the collection of water-quality and streambed-sediment samples at each site. A stream reach was defined by multiplying 10 times the average bankfull channel width in each reach (Leopold and others, 1964; Hynes, 1970). Stream-water samples were collected near the downstream transect of each stream reach.

Stream-Water Sample Collection and Analysis

Stream-water samples were collected by using automatic samplers positioned on the streambanks to obtain concentrations of water-quality constituents at low (normal) stage and high stage. At low stage, the automatic samplers were programmed to collect six 250-milliliter (mL) samples at 4-hour

intervals for 24 hours. These six samples were composited into a single 24-hour sample to represent concentrations during acute exposures of selected trace elements. This process was repeated for 4 consecutive days, and the 4-day average was determined to represent the chronic exposure. A value of 10 percent of the reporting limit was used to calculate 4-day averages for non-detected concentrations. The low-stage and selected replicate samples were collected for 4 consecutive days in December 2015, May 2016, and July 2016 (table 4). Cleaning of equipment and handling of samples followed USGS parts-per-billion protocols (USGS, variously dated). Whole water samples were analyzed for major inorganic ions, trace elements, and nutrients. Filtered samples were collected by using a peristaltic pump to pass water through dedicated tubing and a 0.45-micrometer (µm) cellulose nitrate filter cartridge into the appropriate bottle. Filtered samples were used to determine dissolved organic carbon concentrations and alkalinity. Samples requiring preservation (acidification) were collected in pretreated laboratory-supplied containers. All samples were chilled and sent overnight to RTI Laboratories. Concentrations from the samples collected during low stage and high stage were compared to the acute aquatic-life criteria for selected trace elements.

Table 3. Descriptions of three stream-water sites located near the Peason Ridge training area and two stream-water sites located near the Main Post, Fort Polk Military Reservation, Louisiana.[USGS, U.S. Geological Survey; dec deg, decimal degrees; mi², square mile; km², square kilometer]

Site number (figs. 1–6)	USGS site number (USGS, 2020)	Latitude (dec deg)	Longitude (dec deg)	Watershed area		Site description
				mi²	km²	
Sites near Peason Ridge training area						
Site 1	312238093085501	31.377167	−93.148667	0.96	2.5	Little Kisatchie Bayou near unnamed Forest Service road (upstream site)
Site 2	312323093071901	31.389861	−93.121889	4.2	11	Little Kisatchie Bayou near Forest Service Road 364 (FR364) (downstream site)
Site 3	311620093253601	31.272194	−93.426639	1.1	2.9	Little Sandy Branch upstream of bridge on Highway 392
Sites near the Main Post						
Site 4	311001092353101	31.166833	−92.592056	4.0	10	Longs Branch upstream of dirt road near Forest Service Road (FS277)
Site 5	305809093234201	30.969083	−93.394917	6.7	17	Pocosin Creek upstream of two culverts on Lower Pocosin Road

Wet-weather events (spates) caused high-stage conditions (table 4). The automatic samplers were programmed to collect water for 2 hours after a 1-ft or more increase in stage to produce a single composite sample for the rain event. Attempts were made to collect three event samples between January 2016 and August 2016. During the March event, extremely high water damaged the equipment at sites 4 and 5, thus no samples could be collected. Several attempts were made in July and August to collect samples during the third high-water event, but low amounts of rain prohibited collection by the automatic samplers.

The formulas used to determine the acute and chronic aquatic-life criteria for selected trace elements are listed in table 5. Conversion factors were not applied because the trace element data for stream-water samples in this report are for total concentrations. For EPA and LDEQ criteria, the acute aquatic-life criteria represent the concentration at which species mortality is likely if exceeded over an exposure of 1 to 3 hours. The chronic aquatic-life criteria represent the concentration at which species mortality is likely if exceeded over a 4-day exposure period (EPA, 2002). In this report, samples were collected over a 24-hour period to represent the acute exposure. Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 milligrams per liter (mg/L) for hardness was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015).

The acute aquatic-life criteria used for this study are as follows: the EPA hardness-based aquatic-life criterion maximum concentration (CMC) for cadmium, lead, and zinc; the historical EPA hardness-based CMC and the EPA biotic-ligand-model-(BLM)-based CMC for copper; and the LDEQ hardness-based acute aquatic-life criteria for cadmium, copper,

lead, and zinc (EPA, 2002, 2019a, b; LDEQ, 2015). The chronic aquatic-life criteria used for this study are as follows: the EPA hardness-based aquatic-life criterion continuous concentration (CCC) for cadmium, lead, and zinc; the historical EPA hardness-based CCC and the BLM-based CCC for copper; and the LDEQ hardness-based chronic aquatic-life criteria for cadmium, copper, lead, and zinc (EPA, 2002, 2019a, b; LDEQ, 2015).

The EPA BLM-based CMC and CCC for copper required measurements of temperature and pH and concentrations of dissolved organic carbon, humic acid, calcium, magnesium, sodium, potassium, sulfate, chloride, alkalinity, and sulfide. The average alkalinity concentration for the site was used when alkalinity was not measured in the field for a sample. Humic acid and sulfide were not measured as part of this study. Humic acid concentrations were set to 10 percent, and sulfide concentrations were set to 1.00E–10 mg/L, both of which were the lowest values allowed by the model, as recommended by the EPA for missing parameters (EPA, 2019b). Although concentrations of these constituents are low in these streams, the model is more sensitive to humic acid than sulfide.

Quality-Assurance Data

Water-quality multi-parameter field meters were calibrated at the beginning of each data-collection day following USGS protocols (USGS, variously dated). Field blanks and environmental replicates were collected during each sampling period to ensure the quality of the sample-collection process. As part of the quality-assurance design, about 14 percent of the stream-water samples were either field blanks or environmental replicate samples (Horowitz and others, 1994). None of the water-quality samples were reanalyzed to verify concentrations.

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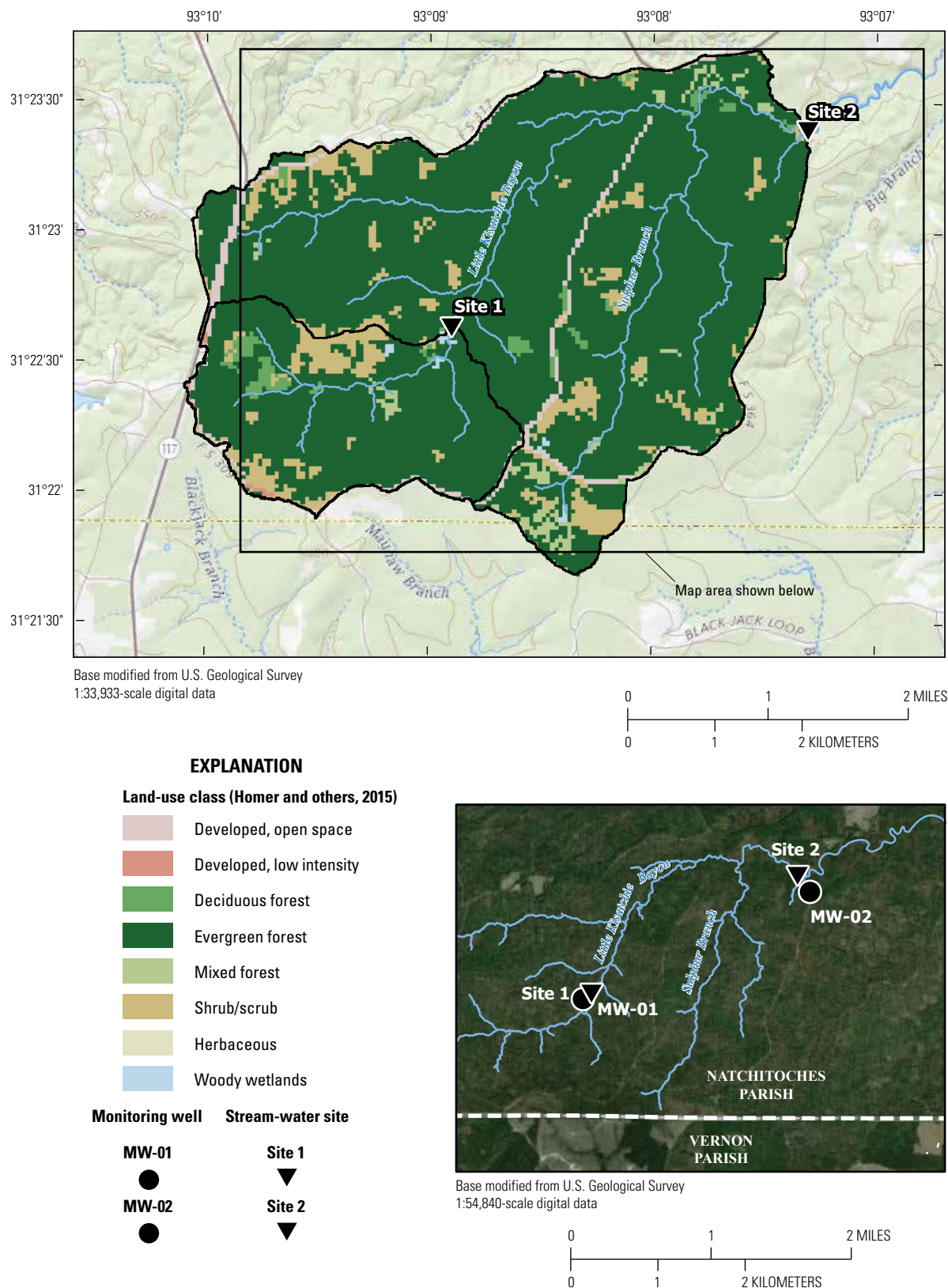


Figure 3. Watershed boundaries, land use, and locations of stream-water sites 1 and 2 and monitoring wells 1 and 2 near the Peason Ridge training area, Fort Polk Military Reservation, Louisiana, December 2015–August 2016.

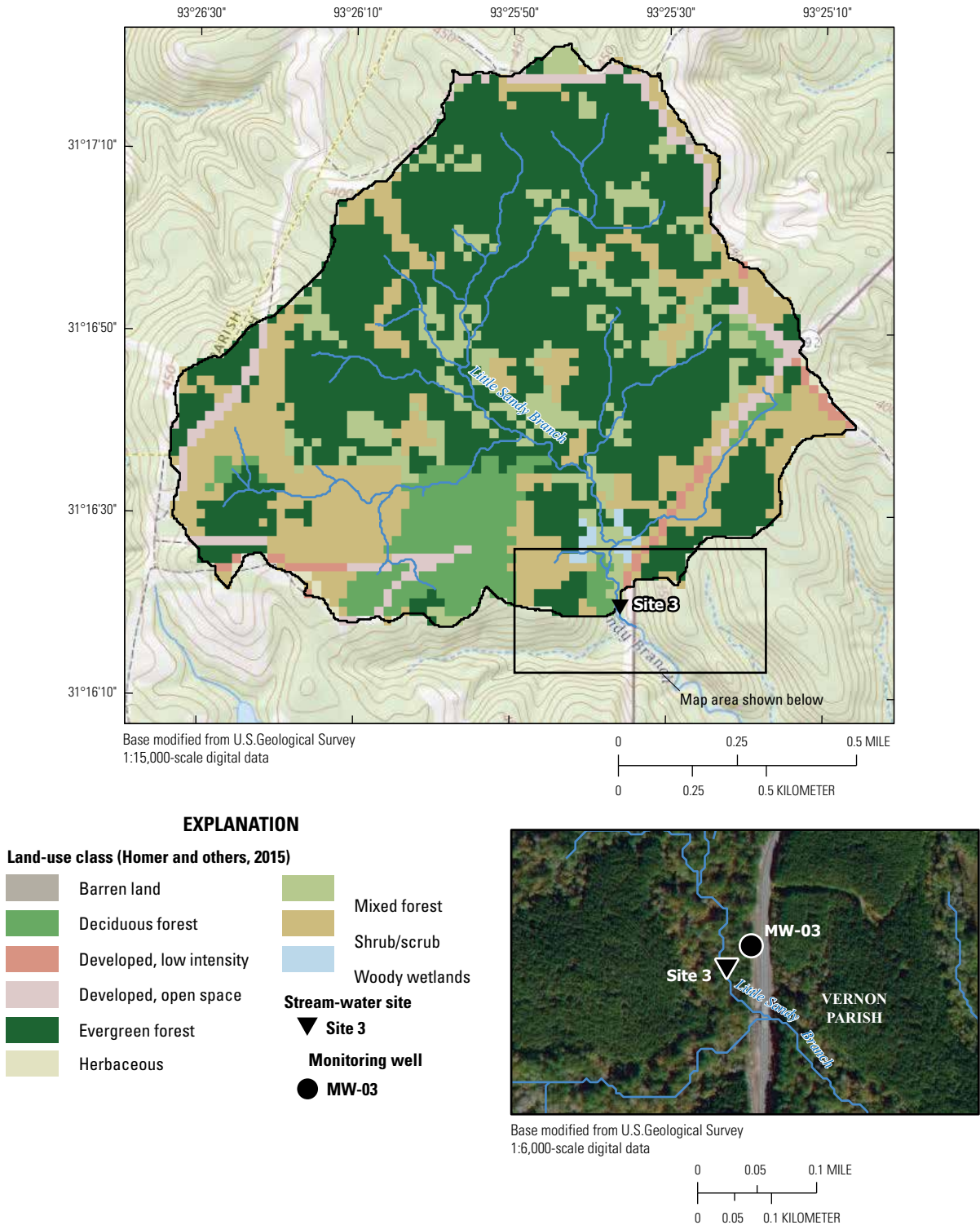


Figure 4. Watershed boundary, land use, and locations of stream-water site 3 and monitoring well 3 near the Peason Ridge training area, Fort Polk Military Reservation, Louisiana, December 2015–August 2016.

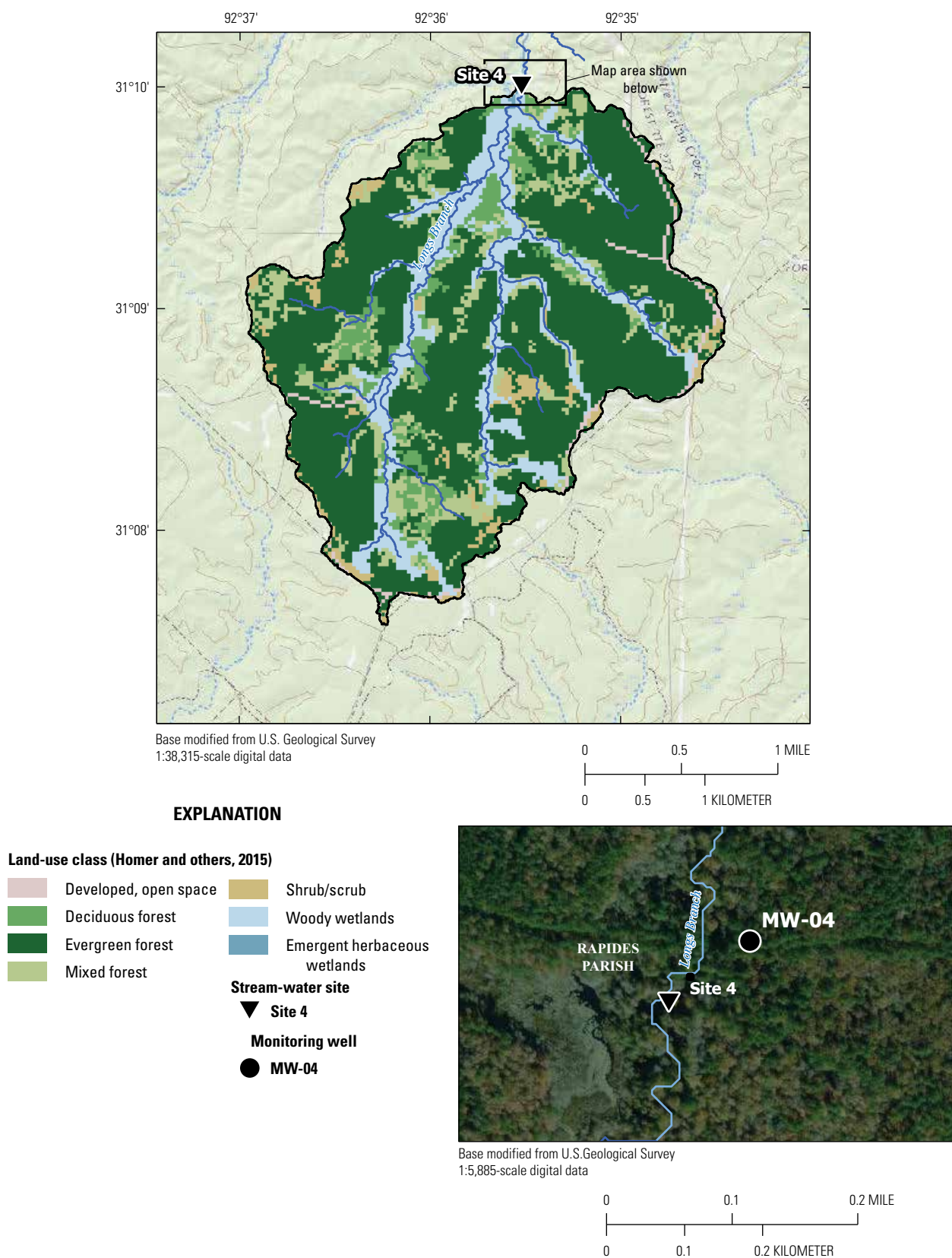


Figure 5. Watershed boundary, land use, and locations of stream-water site 4 and monitoring well 4 near the Main Post at the Fort Polk Military Reservation, December 2015–August 2016.

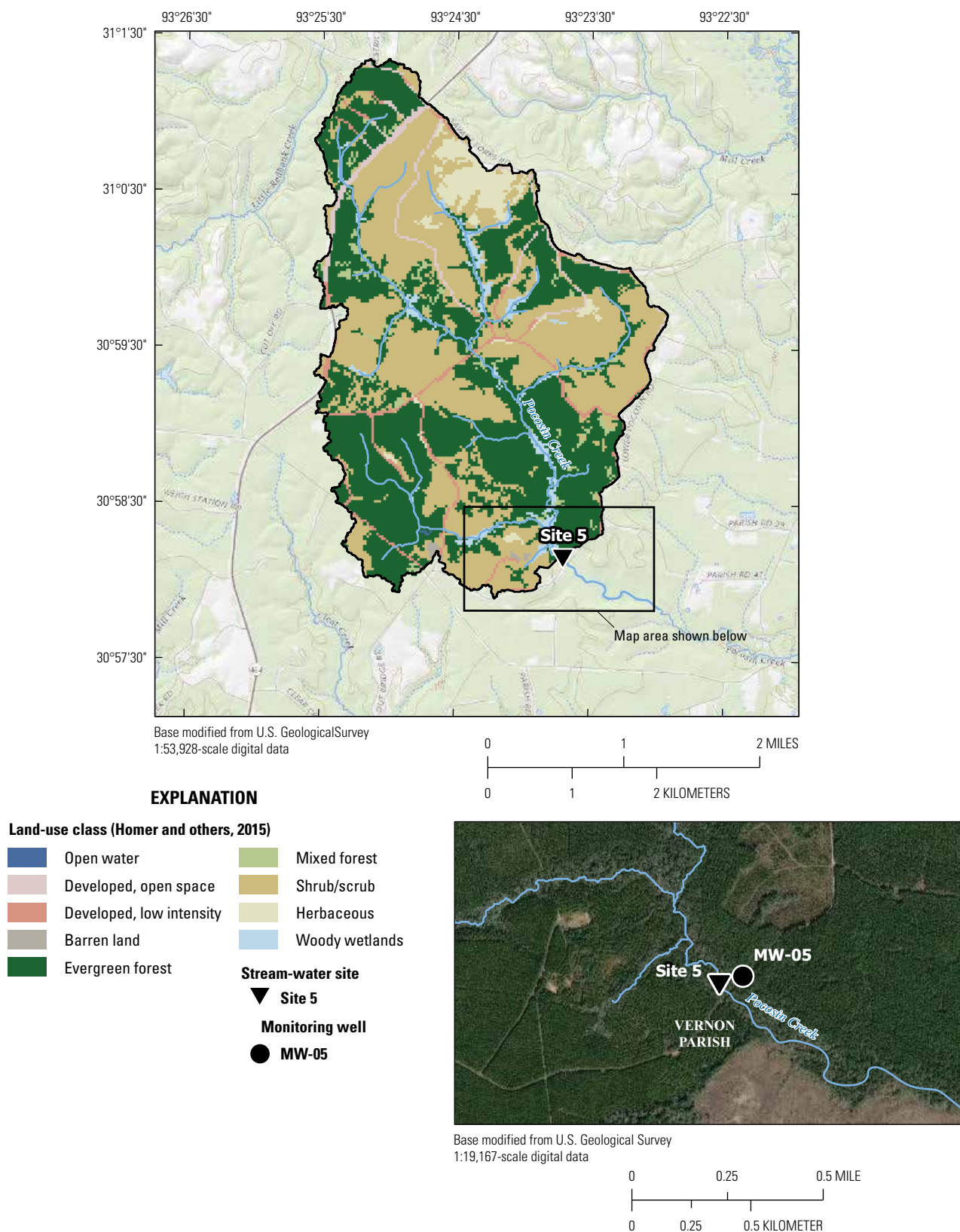


Figure 6. Watershed boundary, land-use, and locations of stream-water site 5 and monitoring well 5 near the Main Post at the Fort Polk Military Reservation, December 2015–August 2016.

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Table 4. Sampling conditions and numbers of composite stream-water samples collected from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, Louisiana, December 2015–July 2016.

[PR, site located near the Peason Ridge training area; MP, site located near the Main Post; SW, stream water; h, hour; R, replicate sample]

Location	Description of sampling condition	Number of samples collected			Total number of samples collected
		December 2015	May 2016	July 2016	
Dry weather, low stage					
Site 1 (PR)	Low (normal)-stage, 24-h composite	4+R	4	4	12+R
Site 2 (PR)	Low (normal)-stage, 24-h composite	4	4+R	4	12+R
Site 3 (PR)	Low (normal)-stage, 24-h composite	4	4	4+R	12+R
Site 4 (MP)	Low (normal)-stage, 24-h composite	4+R	4	4+R	12+2R
Site 5 (MP)	Low (normal)-stage, 24-h composite	4	4+R	4	12+R
Location	Description of sampling condition	Number of samples collected			Total number of samples collected
		March 2016		June 2016	
Wet weather, high stage (water collected after a 1-foot rise in stage for 2 hours)					
Site 1 (PR)	High-stage, 2-h composite	1+R		1	2+R
Site 2 (PR)	High-stage, 2-h composite	1		1	2
Site 3 (PR)	High-stage, 2-h composite	1		1	2
Site 4 (MP)	High-stage, 2-h composite	0		1+R	1+R
Site 5 (MP)	High-stage, 2-h composite	0		1	1

Table 5. Equations used to calculate regulation for determination of acute and chronic aquatic-life criteria for cadmium, copper, lead, and zinc in stream water.

[EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; LDEQ, Louisiana Department of Environmental Quality; Exp, exponential function; CF, conversion factor to obtain dissolved concentration criteria]

Constituent	Regulation type	Equations used to calculate regulation
Cadmium	EPA CMC	$\text{Exp}(0.9789(\ln(\text{hardness}^a)) - 3.866) * \text{CF}^b$
	EPA CCC	$\text{Exp}(0.7977(\ln(\text{hardness}^a)) - 3.909) * \text{CF}^b$
	LDEQ acute	$\text{Exp}(1.1280(\ln(\text{hardness}^a)) - 1.6774) * \text{CF}^b$
	LDEQ chronic	$\text{Exp}(0.7852(\ln(\text{hardness}^a)) - 3.4900) * \text{CF}^b$
Copper	EPA CMC	$\text{Exp}(0.9422(\ln(\text{hardness}^a)) - 1.7000) * \text{CF}^b$
	EPA CCC	$\text{Exp}(0.8545(\ln(\text{hardness}^a)) - 1.7020) * \text{CF}^b$
	LDEQ acute	$\text{Exp}(0.9422(\ln(\text{hardness}^a)) - 1.3844) * \text{CF}^b$
	LDEQ chronic	$\text{Exp}(0.8545(\ln(\text{hardness}^a)) - 1.3860) * \text{CF}^b$
Lead	EPA CMC	$\text{Exp}(1.2730(\ln(\text{hardness}^a)) - 1.4600) * \text{CF}^b$
	EPA CCC	$\text{Exp}(1.2730(\ln(\text{hardness}^a)) - 4.7050) * \text{CF}^b$
	LDEQ acute	$\text{Exp}(1.2730(\ln(\text{hardness}^a)) - 1.4600) * \text{CF}^b$
	LDEQ chronic	$\text{Exp}(1.2730(\ln(\text{hardness}^a)) - 4.7050) * \text{CF}^b$
Zinc	EPA CMC	$\text{Exp}(0.8473(\ln(\text{hardness}^a)) + 0.8840) * \text{CF}^b$
	EPA CCC	$\text{Exp}(0.8473(\ln(\text{hardness}^a)) + 0.8840) * \text{CF}^b$
	LDEQ acute	$\text{Exp}(0.8473(\ln(\text{hardness}^a)) + 0.8604) * \text{CF}^b$
	LDEQ chronic	$\text{Exp}(0.8473(\ln(\text{hardness}^a)) + 0.7614) * \text{CF}^b$

^aA concentration of 25 milligrams per liter (mg/L) for hardness was used to calculate the LDEQ aquatic-life criteria for selected trace elements, namely cadmium, lead, copper, and zinc, when hardness values were low (less than 25 mg/L) in the streams. Refer to [tables 6–9](#) for sample-specific calculations.

^bConversion factors were not applied because the trace element data for stream-water samples in this report are for total concentrations.

Field-blank samples were collected to evaluate contamination that might be introduced from cleaning procedures, sample collection and handling, and analytical procedures. Field-blank samples were collected at three sites: site 2, May 18, 2016; site 3, July 12, 2016; and site 4, December 6, 2015. Field-blank samples were collected by placing open bottles consisting of trace-element free deionized water into the center of the automatic sampler during a 24-hour collection interval, and then processed using the same procedures and equipment as the environmental samples. There were no detected concentrations of cadmium or lead in the field-blank samples. Copper and zinc were detected at a low or estimated concentration in the field-blank sample collected on December 6, 2015 at site 4 and on July 12, 2016 at site 3. The maximum concentration of copper was an estimated concentration of 0.44 µg/L and for zinc an estimated concentration of 5.1 µg/L. These results indicate the potential for a positive bias in environmental sample results, but the environmental data were not adjusted to account for this potential bias. As a result, computations for toxicity of copper and zinc are considered be conservative relative to the ecological criteria.

Environmental replicate samples were collected to assess the effects of sample-collection methods and laboratory-analysis procedures on measurement variability. Eight environmental replicate samples of stream water were collected at the five sites: site 1, December 6, 2015, and March 9, 2016; site 2, May 17, 2016; site 3, July 12, 2016; site 4, December 7, 2015, June 2, 2016, and July 20, 2016; and site 5, May 24, 2016. The relative percent difference (RPD) between the concentrations of a constituent in an environmental sample and in the corresponding replicate environmental sample was calculated by multiplying 100 by the absolute value of the difference between the environmental and replicate concentrations divided by the average of the concentrations. Though environmental replicates were collected for all constituents, only the concentrations of calculated hardness, cadmium, copper, lead, and zinc are discussed in this report. When a nondetected concentration was paired with an estimated concentration, no RPD was calculated. No RPDs were determined for cadmium because all eight concentrations for paired environmental and replicate environmental samples were less than the reporting limit (not detected). RPDs ranged from 0.36 to 13.9 percent for calculated hardness; 4.44 to 106 percent for copper; zero to 109 percent for lead; and 15.4 to 33.3 percent for zinc.

Calculated Aquatic-Life Criteria for Cadmium, Copper, Lead, and Zinc

Aquatic-life criteria for cadmium, copper, lead, and zinc in stream water at five background sites, three near Peason Ridge and two near the Main Post, are necessary for protection of aquatic organisms on the Reservation. Aquatic-life criteria

for these four trace elements were calculated according to Federal and State aquatic-life guidelines by using stream hardness values. The acute aquatic-life criteria used for this study are as follows: the EPA hardness-based aquatic-life CMC for cadmium, lead, and zinc; the historical EPA hardness-based CMC and the BLM-based CMC for copper; and the LDEQ hardness-based acute aquatic-life criteria for cadmium, copper, lead, and zinc. The chronic aquatic-life criteria used for this study are as follows: the EPA hardness-based aquatic-life CCC for cadmium, lead, and zinc; the historical EPA hardness-based CCC and the BLM-based CCC for copper; and the LDEQ hardness-based chronic aquatic-life criteria for cadmium, copper, lead, and zinc (EPA, 2002, 2019b; LDEQ, 2015). Guidelines, criteria, and standards are listed in appendix 2 to provide a frame of reference for water-quality data collected during this study, and values and concentrations used to calculate the BLM-based aquatic-life criteria for copper are listed in appendix 3.

Calculated hardness values in stream-water samples collected at the three sites near Peason Ridge ranged from 3.4 to 16 mg/L (tables 6, 7, 8, and 9), with an average concentration of 6.9 mg/L. Hardness values for stream-water samples collected at the two sites near the Main Post ranged from 3.9 to 14 mg/L (tables 6, 7, 8, and 9), with an average concentration of 7.8 mg/L. Hardness values near Peason Ridge increased seasonally, from an average concentration of 5.9 mg/L for the winter samples to an average concentration of 7.0 mg/L for the spring and summer samples. Hardness values near the Main Post did not appear to fluctuate seasonally, with an average concentration of 7.8 mg/L for the winter samples and an average concentration of 7.9 mg/L for the spring and summer samples. Hardness values near Peason Ridge were greatest in the wet weather, high-stage (spate) samples, with an average concentration of 9.4 mg/L. Hardness values near the Main Post in samples collected during high stage were similar to concentrations in the samples collected during low stage, with an average concentration of 7.6 mg/L.

Cadmium

Cadmium was detected in 1 of the 42 (2 percent) stream-water samples collected at the 3 sites near Peason Ridge (table 6). For sites 1–3, the EPA CMC for cadmium ranged from 0.07 to 0.32 µg/L, and the LDEQ acute criteria was 7.1 µg/L. A cadmium concentration of E0.48 µg/L in a sample collected during high stage at site 2 exceeded the EPA CMC of 0.10 µg/L; however, this concentration did not exceed the LDEQ acute criteria. For sites 1–3, the EPA CCC for cadmium ranged from 0.07 to 0.12 µg/L, and the LDEQ chronic criteria was 0.38 µg/L. No 4-day average concentrations of cadmium exceeded the EPA and LDEQ chronic criteria because all were less than the reporting limit (not detected) at the 3 sites near Peason Ridge.

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Table 6. Calculated aquatic-life criteria for cadmium in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calculate the LDEQ CMC and CCC, in mg/L	Cadmium, total, in µg/L (01027*)	Cadmium, EPA hardness- based CMC (calc), in µg/L	Cadmium, LDEQ hardness- based acute (calc), in µg/L	Cadmium, EPA hardness- based CCC (calc), in µg/L	Cadmium, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 1 east of the Peason Ridge training area										
Site 1	20151205	2000	7.2	25	<1.0	0.14	7.1	---	---	0
Site 1	20151206	2000	6.6	25	<1.0	0.13	7.1	---	---	0
Site 1	20151207	2000	6.5	25	<1.0	0.13	7.1	---	---	0
Site 1	20151208	2300	6.5	25	<1.0	0.13	7.1	---	---	0
Site 1, Dec. 2015, 4-day average			6.7	25	<1.0	---	---	0.09	0.38	0
Site 1**	20160309	1400	8.9**	25	<1.0**	0.18	7.1	---	---	0
Site 1	20160516	0800	6.5	25	<1.0	0.13	7.1	---	---	0
Site 1	20160517	0100	15	25	<1.0	0.30	7.1	---	---	0
Site 1	20160518	0100	5.9	25	<1.0	0.12	7.1	---	---	0
Site 1	20160519	0100	10	25	<1.0	0.20	7.1	---	---	0
Site 1, May 2016, 4-day average			9.4	25	<1.0	---	---	0.12	0.38	0
Site 1**	20160602	1130	6.1**	25	<1.0**	0.12	7.1	---	---	0
Site 1	20160712	0100	6.3	25	<2.0	0.13	7.1	---	---	0
Site 1	20160713	0100	5.9	25	<1.0	0.12	7.1	---	---	0
Site 1	20160714	0100	6.3	25	<1.0	0.13	7.1	---	---	0
Site 1	20160715	0100	6.3	25	<1.0	0.13	7.1	---	---	0
Site 1, July 2016, 4-day average			6.2	25	<1.0	---	---	0.09	0.38	0
Site 2 east of the Peason Ridge training area										
Site 2	20151206	2000	6.1	25	<1.0	0.12	7.1	---	---	0
Site 2	20151208	0800	6.3	25	<1.0	0.13	7.1	---	---	0
Site 2	20151208	2100	5.9	25	<1.0	0.12	7.1	---	---	0
Site 2	20151209	2000	5.7	25	<1.0	0.12	7.1	---	---	0
Site 2, Dec. 2015, 4-day average			6.0	25	<1.0	---	---	0.08	0.38	0
Site 2**	20160309	1500	12**	25	<1.0**	0.24	7.1	---	---	0
Site 2	20160516	1300	6.1	25	<1.0	0.12	7.1	---	---	0
Site 2	20160517	0200	6.1	25	<1.0	0.12	7.1	---	---	0
Site 2	20160518	0200	16	25	<1.0	0.32	7.1	---	---	0
Site 2	20160519	0200	6.5	25	<1.0	0.13	7.1	---	---	0
Site 2, May 2016, 4-day average			8.7	25	<1.0	---	---	0.11	0.38	0

Table 6. Calculated aquatic-life criteria for cadmium in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calculate the LDEQ CMC and CCC, in mg/L	Cadmium, total, in µg/L (01027*)	Cadmium, EPA hardness- based CMC (calc), in µg/L	Cadmium, LDEQ hardness- based acute (calc), in µg/L	Cadmium, EPA hardness- based CCC (calc), in µg/L	Cadmium, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 2 east of the Peason Ridge training area—Continued										
Site 2**	20160602	1200	5.1**	25	E0.48**	0.10	7.1	---	---	1
Site 2	20160712	0200	8.0	25	<2.0	0.16	7.1	---	---	0
Site 2	20160713	0200	8.7	25	<1.0	0.17	7.1	---	---	0
Site 2	20160714	0200	8.4	25	<1.0	0.17	7.1	---	---	0
Site 2	20160715	0200	8.7	25	<1.0	0.17	7.1	---	---	0
Site 2, July 2016, 4-day average			8.5	25	<1.0	---	---	0.11	0.38	0
Site 3 west of the Peason Ridge training area										
Site 3	20151205	2300	5.0	25	<1.0	0.10	7.1	---	---	0
Site 3	20151208	1100	4.8	25	<1.0	0.10	7.1	---	---	0
Site 3	20151209	0100	4.7	25	<1.0	0.10	7.1	---	---	0
Site 3	20151210	0100	5.0	25	<1.0	0.10	7.1	---	---	0
Site 3, Dec. 2015, 4-day average			4.9	25	<1.0	---	---	0.07	0.38	0
Site 3**	20160309	1400	15**	25	<1.0**	0.30	7.1	---	---	0
Site 3	20160516	1500	5.0	25	<1.0	0.10	7.1	---	---	0
Site 3	20160517	0300	3.4	25	<1.0	0.07	7.1	---	---	0
Site 3	20160518	0300	4.6	25	<1.0	0.09	7.4	---	---	0
Site 3	20160519	0300	4.6	25	<1.0	0.09	7.1	---	---	0
Site 3, May 2016, 4-day average			4.4	25	<1.0	---	---	0.07	0.38	0
Site 3**	20160602	1200	---**	25	<1.0**	---	7.1	---	---	0
Site 3	20160712	0300	5.1	25	<2.0	0.10	7.1	---	---	0
Site 3	20160713	0300	4.9	25	<1.0	0.10	7.1	---	---	0
Site 3	20160714	0300	4.8	25	<1.0	0.10	7.1	---	---	0
Site 3	20160715	0300	4.4	25	<1.0	0.09	7.1	---	---	0
Site 3, July 2016, 4-day average			4.8	25	<1.0	---	---	0.07	0.38	0
Site 4 east of the Main Post										
Site 4	20151206	0100	11	25	E0.33	0.22	7.1	---	---	1
Site 4	20151207	0400	11	25	<1.0	0.22	7.1	---	---	0
Site 4	20151208	0600	11	25	<1.0	0.22	7.1	---	---	0
Site 4	20151209	0400	10	25	<1.0	0.20	7.1	---	---	0
Site 4, Dec. 2015, 4-day average			11	25	E0.16	---	---	0.14	0.38	1

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Table 6. Calculated aquatic-life criteria for cadmium in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calculate the LDEQ CMC and CCC, in mg/L	Cadmium, total, in µg/L (01027*)	Cadmium, EPA hardness- based CMC (calc), in µg/L	Cadmium, LDEQ hardness- based acute (calc), in µg/L	Cadmium, EPA hardness- based CCC (calc), in µg/L	Cadmium, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 4 east of the Main Post—Continued										
Site 4	20160523	1000	14	25	<1.0	0.28	7.1	---	---	0
Site 4	20160524	0100	11	25	<1.0	0.22	7.1	---	---	0
Site 4	20160525	0100	10	25	<1.0	0.20	7.1	---	---	0
Site 4	20160526	0100	10	25	<1.0	0.20	7.1	---	---	0
Site 4, May 2016, 4-day average			11	25	<1.0	---	---	0.14	0.38	0
Site 4**	20160602	1500	7.3**	25	<1.0**	0.15	7.1	---	---	0
Site 4	20160718	0100	11	25	<1.0	0.22	7.1	---	---	0
Site 4	20160719	0100	11	25	<1.0	0.22	7.1	---	---	0
Site 4	20160720	0100	12	25	<1.0	0.24	7.1	---	---	0
Site 4	20160721	0100	11	25	<1.0	0.22	7.1	---	---	0
Site 4, July 2016, 4-day average			11	25	<1.0	---	---	0.14	0.38	0
Site 5 west of the Main Post										
Site 5	20151206	0100	4.3	25	<1.0	0.09	7.1	---	---	0
Site 5	20151207	0100	7.2	25	<1.0	0.14	7.1	---	---	0
Site 5	20151208	0100	4.1	25	<1.0	0.08	7.1	---	---	0
Site 5	20151209	0400	4.0	25	<1.0	0.08	7.1	---	---	0
Site 5, Dec. 2015, 4-day average			4.9	25	<1.0	---	---	0.07	0.38	0
Site 5	20160523	1300	4.3	25	<1.0	0.09	7.1	---	---	0
Site 5	20160524	0200	3.9	25	<1.0	0.08	7.1	---	---	0
Site 5	20160525	0200	4.3	25	<1.0	0.09	7.1	---	---	0
Site 5	20160526	0200	4.2	25	<1.0	0.09	7.1	---	---	0
Site 5, May 2016, 4-day average			4.2	25	<1.0	---	---	0.06	0.38	0
Site 5**	20160602	1400	8.0**	25	<1.0**	0.16	7.1	---	---	0
Site 5	20160718	0200	4.7	25	<1.0	0.10	7.1	---	---	0
Site 5	20160719	0200	5.0	25	<1.0	0.10	7.1	---	---	0
Site 5	20160720	0200	4.7	25	<1.0	0.10	7.1	---	---	0
Site 5	20160721	0200	4.7	25	<1.0	0.10	7.1	---	---	0
Site 5, July 2016, 4-day average			4.8	25	<1.0	---	---	0.07	0.38	0

*USGS parameter code; refer to appendix 1.

**Sampled during high stage (spate).

Cadmium was detected in 1 of the 26 (4 percent) stream-water samples collected at the 2 sites near the Main Post (table 6). For sites 4 and 5, the EPA CMC for cadmium ranged from 0.08 to 0.28 µg/L, and LDEQ acute criteria was 7.1 µg/L. A cadmium concentration of E0.33 µg/L in a sample collected during low stage at site 4 exceeded the EPA CMC of 0.22 µg/L; however, this concentration did not exceed the LDEQ acute criteria. Because of the low number of detections, only one 4-day average concentration, E0.16 µg/L at site 4, could be calculated for cadmium. For sites 4 and 5, the EPA CCC for cadmium ranged from 0.06 to 0.14 µg/L, and the LDEQ chronic criteria was 0.38 µg/L. The 4-day average concentration at site 4 exceeded the EPA CCC but did not exceed the LDEQ chronic criteria.

Copper

Copper was detected in 34 of the 42 (81 percent) stream-water samples collected at the 3 sites near Peason Ridge, with detected concentrations ranging from E0.26 to E4.2 µg/L (table 7). Copper concentrations typically were higher in the samples collected during high stage near Peason Ridge than in those collected during low stage. For sites 1–3, the historical EPA CMC for copper ranged from 0.58 to 2.5 µg/L, the EPA BLM-based CMC ranged from 0.26 to 16 µg/L, and the LDEQ acute criteria was 5.2 µg/L. Copper concentrations exceeded the historical EPA CMC in 12 samples and the EPA BLM-based CMC in 5 samples, though none exceeded the LDEQ acute criteria. For sites 1–3, the nine 4-day average concentrations of copper ranged from E0.40 to E2.0 µg/L. The historical EPA CCC for copper ranged from 0.65 to 1.2 µg/L, the EPA BLM-based CCC ranged from 0.27 to 3.6 µg/L, and the LDEQ chronic criteria was 3.9 µg/L. The 4-day average concentrations exceeded the historical EPA CCC for copper in 4 samples and the EPA BLM-based CCC in 3 samples, though no concentrations of copper exceeded the LDEQ chronic criteria at the 3 sites near Peason Ridge.

Copper was detected in 22 of the 26 (85 percent) stream-water samples collected at the 2 sites near the Main Post, with detected concentrations ranging from E0.32 to E2.5 µg/L (table 7). For sites 4 and 5, the historical EPA CMC for copper ranged from 0.66 to 2.2 µg/L, the EPA BLM-based CMC ranged from 0.29 to 9.1 µg/L, and the LDEQ chronic criteria was 5.2 µg/L. Copper concentrations exceeded the historical EPA CMC in 9 samples and the EPA BLM-based CMC in 10 samples, though no concentrations of copper exceeded the LDEQ acute criteria. For sites 4 and 5, the six 4-day average concentrations ranged from E0.45 to E1.7 µg/L. The historical EPA CCC for copper ranged from 0.62 to E1.4 µg/L, the EPA BLM-based CCC ranged from 0.23 to 1.3 µg/L, and the LDEQ chronic criteria was 3.9 µg/L. The 4-day average concentrations exceeded the historical EPA CCC for copper in

3 samples and the EPA BLM-based CCC in 4 samples, though none exceeded the LDEQ chronic criteria at the 2 sites near the Main Post.

Lead

Lead was detected in 31 of the 42 (74 percent) stream-water samples collected at the 3 sites near Peason Ridge, with detected concentrations ranging from E0.24 to 6.0 µg/L (table 8). For sites 1–3, the EPA CMC for lead ranged from 1.1 to 7.9 µg/L, and the LDEQ acute criteria was 14 µg/L. One lead concentration, 6.0 µg/L in a sample collected during high stage at site 2, exceeded the EPA CMC of 5.5 µg/L. No concentrations of lead exceeded the LDEQ acute criteria. For sites 1–3, the nine 4-day average concentrations ranged from E0.17 to E0.64 µg/L. The EPA CCC ranged from 0.06 to 0.16 µg/L, and the LDEQ chronic criteria was 0.54 µg/L. Nine 4-day average concentrations exceeded the historical EPA CCC for lead, and two 4-day average concentrations exceeded the LDEQ chronic criteria at the 3 sites near Peason Ridge.

Lead was detected in 16 of the 26 (62 percent) stream-water samples collected at the 2 sites near the Main Post, with detected concentrations ranging from E0.24 to 4.1 µg/L (table 8). For sites 4 and 5, the EPA CMC for lead ranged from 1.3 to 6.7 µg/L, and the LDEQ acute criteria was 14 µg/L. One lead concentration, 4.1 µg/L in a sample collected during high stage at site 4, exceeded the EPA CMC of 2.9 µg/L. No concentrations of lead exceeded the LDEQ acute criteria. For sites 4 and 5, the six 4-day average concentrations at the two sites near the Main Post ranged from not detected (<1.0 µg/L) to E0.50 µg/L. The EPA CCC for lead ranged from 0.06 to 0.19 µg/L, and the LDEQ chronic criteria was 0.54 µg/L. Near the Main Post, all three 4-day average concentrations at site 5 exceeded the EPA CCC for lead though none exceeded the LDEQ chronic criteria.

Zinc

Zinc was detected in 35 of the 42 (83 percent) stream-water samples collected at the 3 sites near Peason Ridge, with detected concentrations ranging from E2 to 100 µg/L (table 9). For sites 1–3, the EPA CMC ranged from 6.7 to 25 µg/L, and the LDEQ acute criteria was 36 µg/L. One zinc concentration, 100 µg/L at site 3, exceeded the EPA CMC of 8.9 µg/L and the LDEQ acute criteria of 36 µg/L; however, no reruns were requested to further verify this concentration. For sites 1–3, the nine 4-day average concentrations ranged from E3 to E28 µg/L. The EPA CCC ranged from 7.5 to 14 µg/L, and the LDEQ chronic criteria was 33 µg/L. One 4-day average zinc concentration, E28 µg/L at site 3, exceeded the EPA CCC of 8.2 µg/L. No 4-day average concentrations of zinc exceeded the LDEQ chronic aquatic-life criteria at the 3 sites near Peason Ridge.

Table 7. Calculated aquatic-life criteria for copper in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; BLM, biotic ligand model; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; mg/L, milligram per liter; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Copper, total, in µg/L (01042*)	Copper, historical EPA hardness- based CMC (calc), in µg/L	Copper, EPA BLM- based CMC (calc), in µg/L**	Copper, LDEQ hardness- based acute (calc), in µg/L	Copper, historical EPA hardness- based CCC (calc), in µg/L	Copper, EPA BLM- based CCC (calc), in µg/L**	Copper, LDEQ hardness- based chronic (calc), in µg/L	Number of exceedances
Site 1 east of the Peason Ridge training area												
Site 1	20151205	2000	7.2	25	E0.66	1.2	1.2	5.2	---	---	---	0
Site 1	20151206	2000	6.6	25	E0.54	1.1	1.8	5.2	---	---	---	0
Site 1	20151207	2000	6.5	25	E0.64	1.1	0.80	5.2	---	---	---	0
Site 1	20151208	2300	6.5	25	E0.44	1.1	0.92	5.2	---	---	---	0
Site 1, Dec. 2015, 4-day average			6.7	25	E0.57	---	---	---	0.93	0.71	3.9	0
Site 1***	20160309	1400	8.9***	25	E2.2***	1.4	7.8	5.2	---	---	---	1
Site 1	20160516	0800	6.5	25	<5.0	1.1	1.7	5.2	---	---	---	0
Site 1	20160517	0100	15	25	E0.87	2.3	2.0	5.2	---	---	---	0
Site 1	20160518	0100	5.9	25	E0.28	1.0	2.1	5.2	---	---	---	0
Site 1	20160519	0100	10	25	<5.0	1.6	2.5	5.2	---	---	---	0
Site 1, May 2016, 4-day average			9.4	25	E0.54	---	---	---	1.2	1.2	3.9	0
Site 1***	20160602	1130	6.1***	25	E1.4***	1.0	16	5.2	---	---	---	1
Site 1	20160712	0100	6.3	25	E1.9	1.0	3.3	5.2	---	---	---	1
Site 1	20160713	0100	5.9	25	E0.57	1.0	2.2	5.2	---	---	---	0
Site 1	20160714	0100	6.3	25	E1.3	1.0	4.3	5.2	---	---	---	1
Site 1	20160715	0100	6.3	25	E1.9	1.0	4.0	5.2	---	---	---	1
Site 1, July 2016, 4-day average			6.2	25	E1.4	---	---	---	0.87	2.2	3.9	1
Site 2 east of the Peason Ridge training area												
Site 2	20151206	2000	6.1	25	E0.96	1.0	1.1	5.2	---	---	---	0
Site 2	20151208	0800	6.3	25	E0.88	1.0	2.3	5.2	---	---	---	0
Site 2	20151208	2100	5.9	25	E0.48	1.0	0.99	5.2	---	---	---	0
Site 2	20151209	2000	5.7	25	E0.77	0.94	0.95	5.2	---	---	---	0
Site 2, Dec. 2015, 4-day average			6.0	25	E0.77	---	---	---	0.84	0.78	3.9	0

Table 7. Calculated aquatic-life criteria for copper in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; BLM, biotic ligand model; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; mg/L, milligram per liter; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Copper, total, in µg/L (01042*)	Copper, historical EPA hardness- based CMC (calc), in µg/L	Copper, EPA BLM- based CMC (calc), in µg/L**	Copper, LDEQ hardness- based acute (calc), in µg/L	Copper, historical EPA hardness- based CCC (calc), in µg/L	Copper, EPA BLM- based CCC (calc), in µg/L**	Copper, LDEQ hardness- based chronic (calc), in µg/L	Number of exceedances
Site 2 east of the Peason Ridge training area—Continued												
Site 2***	20160309	1500	12***	25	E4.2***	1.9	6.6	5.2	---	---	---	1
Site 2	20160516	1300	6.1	25	E0.54	1.0	2.1	5.2	---	---	---	0
Site 2	20160517	0200	6.1	25	E1.0	1.0	3.4	5.2	---	---	---	0
Site 2	20160518	0200	16	25	E0.84	2.5	2.1	5.2	---	---	---	0
Site 2	20160519	0200	6.5	25	<5.0	1.1	2.9	5.2	---	---	---	0
Site 2, May 2016, 4-day average			8.7	25	E0.72	---	---	---	1.2	1.5	3.9	0
Site 2***	20160602	1200	5.1***	25	E0.88***	0.85	9.2	5.2	---	---	---	1
Site 2	20160712	0200	8.0	25	E1.3	1.3	7.0	5.2	---	---	---	0
Site 2	20160713	0200	8.7	25	E1.0	1.4	3.3	5.2	---	---	---	0
Site 2	20160714	0200	8.4	25	E4.2	1.4	6.3	5.2	---	---	---	1
Site 2	20160715	0200	8.7	25	E1.4	1.4	6.0	5.2	---	---	---	0
Site 2, July 2016, 4-day average			8.5	25	E2.0	---	---	---	1.1	3.6	3.9	1
Site 3 west of the Peason Ridge training area												
Site 3	20151205	2300	5.0	25	E0.68	0.83	1.9	5.2	---	---	---	0
Site 3	20151208	1100	4.8	25	E0.94	0.80	0.28	5.2	---	---	---	2
Site 3	20151209	0100	4.7	25	<5.0	0.79	0.27	5.2	---	---	---	0
Site 3	20151210	0100	5.0	25	E0.88	0.83	0.31	5.2	---	---	---	2
Site 3, Dec. 2015, 4-day average			4.9	25	E0.75	---	---	---	0.71	0.32	3.9	1
Site 3***	20160309	1400	15***	25	E2.3***	2.3	2.8	5.2	---	---	---	0
Site 3	20160516	1500	5.0	25	<5.0	0.83	0.31	5.2	---	---	---	0
Site 3	20160517	0300	3.4	25	E0.34	0.58	0.56	5.2	---	---	---	0
Site 3	20160518	0300	4.6	25	E0.26	0.77	0.48	5.2	---	---	---	0
Site 3	20160519	0300	4.6	25	<5.0	0.77	0.43	5.2	---	---	---	0

Table 7. Calculated aquatic-life criteria for copper in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; BLM, biotic ligand model; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; mg/L, milligram per liter; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Copper, total, in µg/L (01042*)	Copper, historical EPA hardness- based CMC (calc), in µg/L	Copper, EPA BLM- based CMC (calc), in µg/L**	Copper, LDEQ hardness- based acute (calc), in µg/L	Copper, historical EPA hardness- based CCC (calc), in µg/L	Copper, EPA BLM- based CCC (calc), in µg/L**	Copper, LDEQ hardness- based chronic (calc), in µg/L	Number of exceedances
Site 3 west of the Peason Ridge training area—Continued												
Site 3, May 2016, 4-day average			4.4	25	E0.40	---	---	---	0.65	0.29	3.9	0
Site 3***	20160602	1200	---***	25	<5.0***	---	11.1	5.2	---	---	---	0
Site 3	20160712	0300	5.1	25	<10	0.85	0.70	5.2	---	---	---	0
Site 3	20160713	0300	4.9	25	E0.81	0.82	0.38	5.2	---	---	---	1
Site 3	20160714	0300	4.8	25	E0.86	0.80	0.30	5.2	---	---	---	2
Site 3	20160715	0300	4.4	25	E1.4	0.74	0.26	5.2	---	---	---	2
Site 3, July 2016, 4-day average			4.8	25	E1.0	---	---	---	0.70	0.27	3.9	2
Site 4 east of the Main Post												
Site 4	20151206	0100	11	25	E0.80	1.7	0.71	5.2	---	---	---	1
Site 4	20151207	0400	11	25	E0.61	1.7	0.98	5.2	---	---	---	0
Site 4	20151208	0600	11	25	E0.38	1.7	0.79	5.2	---	---	---	0
Site 4	20151209	0400	10	25	<5.0	1.6	0.81	5.2	---	---	---	0
Site 4, Dec. 2015, 4-day average			11	25	E0.57	---	---	---	1.4	0.57	3.9	0
Site 4	20160523	1000	14	25	E0.42	2.2	0.95	5.2	---	---	---	0
Site 4	20160524	0100	11	25	E0.40	1.7	0.85	5.2	---	---	---	0
Site 4	20160525	0100	10	25	<5.0	1.6	0.85	5.2	---	---	---	0
Site 4	20160526	0100	10	25	<5.0	1.6	0.78	5.2	---	---	---	0
Site 4, May 2016, 4-day average			11	25	E0.45	---	---	---	1.4	0.53	3.9	0
Site 4***	20160602	1500	7.3***	25	E2.2***	1.2	9.1	5.2	---	---	---	1
Site 4	20160718	0100	11	25	E2.5	1.7	1.3	5.2	---	---	---	2
Site 4	20160719	0100	11	25	E1.8	1.7	1.8	5.2	---	---	---	1
Site 4	20160720	0100	12	25	E1.5	1.9	2.4	5.2	---	---	---	0
Site 4	20160721	0100	11	25	E1.1	1.7	2.1	5.2	---	---	---	0

Table 7. Calculated aquatic-life criteria for copper in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; BLM, biotic ligand model; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; mg/L, milligram per liter; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Copper, total, in µg/L (01042*)	Copper, historical EPA hardness- based CMC (calc), in µg/L	Copper, EPA BLM- based CMC (calc), in µg/L**	Copper, LDEQ hardness- based acute (calc), in µg/L	Copper, historical EPA hardness- based CCC (calc), in µg/L	Copper, EPA BLM- based CCC (calc), in µg/L**	Copper, LDEQ hardness- based chronic (calc), in µg/L	Number of exceedances
Site 4 east of the Main Post—Continued												
Site 4, July 2016, 4-day average			11	25	E1.7	---	---	---	1.4	1.3	3.9	2
Site 5 west of the Main Post												
Site 5	20151206	0100	4.3	25	E0.63	0.72	0.54	5.2	---	---	---	1
Site 5	20151207	0100	7.2	25	E0.63	1.2	0.55	5.2	---	---	---	1
Site 5	20151208	0100	4.1	25	E0.46	0.69	0.29	5.2	---	---	---	1
Site 5	20151209	0400	4.0	25	E1.3	0.67	0.30	5.2	---	---	---	2
Site 5, Dec. 2015, 4-day average			4.9	25	E0.76	---	---	---	0.71	0.23	3.9	2
Site 5	20160523	1300	4.3	25	E0.60	0.72	0.55	5.2	---	---	---	1
Site 5	20160524	0200	3.9	25	E0.53	0.66	0.51	5.2	---	---	---	1
Site 5	20160525	0200	4.3	25	<5.0	0.72	0.41	5.2	---	---	---	0
Site 5	20160526	0200	4.2	25	E0.32	0.71	0.42	5.2	---	---	---	0
Site 5, May 2016, 4-day average			4.2	25	E0.49	---	---	---	0.62	0.33	3.9	1
Site 5***	20160602	1400	8.0***	25	E1.6***	1.3	2.2	5.2	---	---	---	1
Site 5	20160718	0200	4.7	25	E2.4	0.79	0.56	5.2	---	---	---	2
Site 5	20160719	0200	5.0	25	E1.5	0.83	0.94	5.2	---	---	---	2
Site 5	20160720	0200	4.7	25	E1.2	0.79	1.6	5.2	---	---	---	1
Site 5	20160721	0200	4.7	25	E0.88	0.79	2.1	5.2	---	---	---	1
Site 5, July 2016, 4-day average			4.8	25	E1.5	---	---	---	0.70	0.68	3.9	2

*USGS parameter code; refer to appendix 1.

**Concentrations of humic acid and sulfide were estimated for calculating the BLM-based CMCs and CCCs.

***Sampled during high stage (spate).

Table 8. Calculated aquatic-life criteria for lead in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Lead, total, in µg/L (01051*)	Lead, USEPA hardness- based CMC (calc), in µg/L	Lead, LDEQ hardness- based acute (calc), in µg/L	Lead, USEPA hardness- based CCC (calc), in µg/L	Lead, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 1 east of the Peason Ridge training area										
Site 1	20151205	2000	7.2	25	E0.31	2.9	14	---	---	0
Site 1	20151206	2000	6.6	25	E0.28	2.6	14	---	---	0
Site 1	20151207	2000	6.5	25	E0.28	2.5	14	---	---	0
Site 1	20151208	2300	6.5	25	E0.28	2.5	14	---	---	0
Site 1, Dec. 2015, 4-day average			6.7	25	E0.29	---	---	0.10	0.54	1
Site 1**	20160309	1400	8.9**	25	2.5**	3.8	14	---	---	0
Site 1	20160309	1400	6.5	25	E0.82	2.5	14	---	---	0
Site 1	20160516	0800	15	25	1.2	7.3	14	---	---	0
Site 1	20160517	0100	5.9	25	E0.44	2.2	14	---	---	0
Site 1	20160518	0100	10	25	<1.0	4.4	14	---	---	0
Site 1, May 2016, 4-day average			9.4	25	E0.64	---	---	0.16	0.54	2
Site 1**	20160602	1130	6.1**	25	2.1**	2.3	14	---	---	0
Site 1	20160712	0100	6.3	25	<2.0	2.4	14	---	---	0
Site 1	20160713	0100	5.9	25	E0.24	2.2	14	---	---	0
Site 1	20160714	0100	6.3	25	<1.0	2.4	14	---	---	0
Site 1	20160715	0100	6.3	25	E0.28	2.4	14	---	---	0
Site 1, July 2016, 4-day average			6.2	25	E0.20	---	---	0.09	0.54	1
Site 2 east of the Peason Ridge training area										
Site 2	20151206	2000	6.1	25	E0.56	2.3	14	---	---	0
Site 2	20151208	0800	6.3	25	E0.48	2.4	14	---	---	0
Site 2	20151208	2100	5.9	25	E0.38	2.2	14	---	---	0
Site 2	20151209	2000	5.7	25	E0.60	2.1	14	---	---	0
Site 2, Dec. 2015, 4-day average			6.0	25	E0.51	---	---	0.09	0.54	1
Site 2**	20160309	1500	12**	25	6.0**	5.5	14	---	---	1
Site 2	20160516	1300	6.1	25	E0.59	2.3	14	---	---	0
Site 2	20160517	0200	6.1	25	1.3	2.3	14	---	---	0
Site 2	20160518	0200	16	25	E0.57	7.9	14	---	---	0
Site 2	20160519	0200	6.5	25	<1.0	2.5	14	---	---	0
Site 2, May 2016, 4-day average			8.7	25	E0.64	---	---	0.14	0.54	2
Site 2**	20160602	1200	5.1**	25	E0.98**	1.8	14	---	---	0
Site 2	20160712	0200	8.0	25	<2.0	3.3	14	---	---	0
Site 2	20160713	0200	8.7	25	E0.36	3.6	14	---	---	0
Site 2	20160714	0200	8.4	25	E0.36	3.5	14	---	---	0

Table 8. Calculated aquatic-life criteria for lead in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Lead, total, in µg/L (01051*)	Lead, USEPA hardness- based CMC (calc), in µg/L	Lead, LDEQ hardness- based acute (calc), in µg/L	Lead, USEPA hardness- based CCC (calc), in µg/L	Lead, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 2 east of the Peason Ridge training area—Continued										
Site 2	20160715	0200	8.7	25	E0.38	3.6	14	---	---	0
Site 2, July 2016, 4-day average			8.5	25	E0.32	---	---	0.14	0.54	1
Site 3 west of the Peason Ridge training area										
Site 3	20151205	2300	5.0	25	E0.32	1.8	14	---	---	0
Site 3	20151208	1100	4.8	25	E0.30	1.7	14	---	---	0
Site 3	20151209	0100	4.7	25	<1.0	1.7	14	---	---	0
Site 3	20151210	0100	5.0	25	E0.28	1.8	14	---	---	0
Site 3, Dec. 2015, 4-day average			4.9	25	E0.25	---	---	0.07	0.54	1
Site 3**	20160309	1400	15**	25	2.50**	7.3	14	---	---	0
Site 3	20160516	1500	5.0	25	E0.32	1.8	14	---	---	0
Site 3	20160517	0300	3.4	25	1.1	1.1	14	---	---	0
Site 3	20160518	0300	4.6	25	E0.29	1.6	14	---	---	0
Site 3	20160519	0300	4.6	25	<1.0	1.6	14	---	---	0
Site 3, May 2016, 4-day average			4.4	25	E0.45	---	---	0.06	0.54	1
Site 3**	20160602	1200	---**	25	<1.0**	---	14	---	---	0
Site 3	20160712	0300	5.1	25	<2.0	1.8	14	---	---	0
Site 3	20160713	0300	4.9	25	<1.0	1.8	14	---	---	0
Site 3	20160714	0300	4.8	25	<1.0	1.7	14	---	---	0
Site 3	20160715	0300	4.4	25	E0.27	1.5	14	---	---	0
Site 3, July 2016, 4-day average			4.8	25	E0.17	---	---	0.07	0.54	1
Site 4 east of the Main Post										
Site 4	20151206	0100	11	25	E0.27	4.9	14	---	---	0
Site 4	20151207	0400	11	25	<1.0	4.9	14	---	---	0
Site 4	20151208	0600	11	25	<1.0	4.9	14	---	---	0
Site 4	20151209	0400	10	25	<1.0	4.4	14	---	---	0
Site 4, Dec. 2015, 4-day average			11	25	E0.14	---	---	0.19	0.54	0
Site 4	20160523	1000	14	25	<1.0	6.7	14	---	---	0
Site 4	20160524	0100	11	25	E0.34	4.9	14	---	---	0
Site 4	20160525	0100	10	25	<1.0	4.4	14	---	---	0
Site 4	20160526	0100	10	25	<1.0	4.4	14	---	---	0
Site 4, May 2016, 4-day average			11	25	E0.16	---	---	0.19	0.54	0
Site 4**	20160602	1500	7.3**	25	4.1**	2.9	14	---	---	1
Site 4	20160718	0100	11	25	<1.0	4.9	14	---	---	0

Table 8. Calculated aquatic-life criteria for lead in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Lead, total, in µg/L (01051*)	Lead, USEPA hardness- based CMC (calc), in µg/L	Lead, LDEQ hardness- based acute (calc), in µg/L	Lead, USEPA hardness- based CCC (calc), in µg/L	Lead, LDEQ hardness- based chronic (calc), in µg/L	Number of exceed- ances
Site 4 east of the Main Post—Continued										
Site 4	20160719	0100	11	25	<1.0	4.9	14	---	---	0
Site 4	20160720	0100	12	25	<1.0	5.5	14	---	---	0
Site 4	20160721	0100	11	25	<1.0	4.9	14	---	---	0
Site 4, July 2016, 4-day average			11	25	<1.0	---	---	0.19	0.54	0
Site 5 west of the Main Post										
Site 5	20151206	0100	4.3	25	E0.30	1.5	14	---	---	0
Site 5	20151207	0100	7.2	25	E0.34	2.9	14	---	---	0
Site 5	20151208	0100	4.1	25	E0.24	1.4	14	---	---	0
Site 5	20151209	0400	4.0	25	E0.33	1.4	14	---	---	0
Site 5, Dec. 2015, 4-day average			4.9	25	E0.30	---	---	0.07	0.54	1
Site 5	20160523	1300	4.3	25	E0.74	1.5	14	---	---	0
Site 5	20160524	0200	3.9	25	E0.44	1.3	14	---	---	0
Site 5	20160525	0200	4.3	25	E0.38	1.5	14	---	---	0
Site 5	20160526	0200	4.2	25	E0.43	1.4	14	---	---	0
Site 5, May 2016, 4-day average			4.2	25	E0.50	---	---	0.06	0.54	1
Site 5**	20160602	1400	8.0**	25	2.0**	3.3	14	---	---	0
Site 5	20160718	0200	4.7	25	E0.32	1.7	14	---	---	0
Site 5	20160719	0200	5.0	25	E0.32	1.8	14	---	---	0
Site 5	20160720	0200	4.7	25	E0.30	1.7	14	---	---	0
Site 5	20160721	0200	4.7	25	E0.30	1.7	14	---	---	0
Site 5, July 2016, 4-day average			4.8	25	E0.31	---	---	0.07	0.54	1

*USGS parameter code; refer to appendix 1.

**Sampled during high stage (spate).

Table 9. Calculated aquatic-life criteria for zinc in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Zinc, total, in µg/L (01092*)	Zinc, hardness- based EPA CMC (calc), in µg/L	Zinc, hardness- based LDEQ acute (calc), in µg/L	Zinc, hardness- based EPA CCC (calc), in µg/L	Zinc, hardness- based LDEQ chronic (calc), in µg/L	Number of exceedances
Site 1 east of the Peason Ridge training area										
Site 1	20151205	2000	7.2	25	E2	13	36	---	---	0
Site 1	20151206	2000	6.6	25	<50	12	36	---	---	0
Site 1	20151207	2000	6.5	25	E3	12	36	---	---	0
Site 1	20151208	2300	6.5	25	E2	12	36	---	---	0
Site 1, Dec. 2015, 4-day average			6.7	25	E3	---	---	11	33	0
Site 1**	20160309	1400	8.9**	25	E7**	15	36	---	---	0
Site 1	20160516	0800	6.5	25	E2	12	36	---	---	0
Site 1	20160517	0100	15	25	E2	23	36	---	---	0
Site 1	20160518	0100	5.9	25	E5	11	36	---	---	0
Site 1	20160519	0100	10	25	<50	17	36	---	---	0
Site 1, May 2016, 4-day average			9.4	25	E3	---	---	14	33	0
Site 1**	20160602	1130	6.1**	25	<50**	11	36	---	---	0
Site 1	20160712	0100	6.3	25	<100	11	36	---	---	0
Site 1	20160713	0100	5.9	25	E6	11	36	---	---	0
Site 1	20160714	0100	6.3	25	E6	11	36	---	---	0
Site 1	20160715	0100	6.3	25	E7	11	36	---	---	0
Site 1, July 2016, 4-day average			6.2	25	E7	---	---	10	33	0
Site 2 east of the Peason Ridge training area										
Site 2	20151206	2000	6.1	25	E3	11	36	---	---	0
Site 2	20151208	0800	6.3	25	E2	11	36	---	---	0
Site 2	20151208	2100	5.9	25	E2	11	36	---	---	0
Site 2	20151209	2000	5.7	25	E6	10	36	---	---	0
Site 2, Dec. 2015, 4-day average			6.0	25	E3	---	---	10	33	0
Site 2**	20160309	1500	12**	25	E9**	20	36	---	---	0
Site 2	20160516	1300	6.1	25	E3	11	36	---	---	0
Site 2	20160517	0200	6.1	25	E3	11	36	---	---	0
Site 2	20160518	0200	16	25	E3	25	36	---	---	0
Site 2	20160519	0200	6.5	25	E3	12	36	---	---	0
Site 2, May 2016, 4-day average			8.7	25	E3	---	---	13	33	0

Table 9. Calculated aquatic-life criteria for zinc in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Zinc, total, in µg/L (01092*)	Zinc, hardness- based EPA CMC (calc), in µg/L	Zinc, hardness- based LDEQ acute (calc), in µg/L	Zinc, hardness- based EPA CCC (calc), in µg/L	Zinc, hardness- based LDEQ chronic (calc), in µg/L	Number of exceedances
Site 2 east of the Peason Ridge training area—Continued										
Site 2**	20160602	1200	5.1**	25	<50**	10	36	---	---	0
Site 2	20160712	0200	8.0	25	E5	14	36	---	---	0
Site 2	20160713	0200	8.7	25	E7	15	36	---	---	0
Site 2	20160714	0200	8.4	25	E7	14	36	---	---	0
Site 2	20160715	0200	8.7	25	E7	15	36	---	---	0
Site 2, July 2016, 4-day average			8.5	25	E6	---	---	13	33	0
Site 3 west of the Peason Ridge training area										
Site 3	20151205	2300	5.0	25	E2	9.2	36	---	---	0
Site 3	20151208	1100	4.8	25	100	8.9	36	---	---	2
Site 3	20151209	0100	4.7	25	E2	8.8	36	---	---	0
Site 3	20151210	0100	5.0	25	E6	9.2	36	---	---	0
Site 3, Dec. 2015, 4-day average			4.9	25	E28	---	---	8.2	33	1
Site 3**	20160309	1400	15**	25	E5**	24	36	---	---	0
Site 3	20160516	1500	5.0	25	E3	9.2	36	---	---	0
Site 3	20160517	0300	3.4	25	E3	6.7	36	---	---	0
Site 3	20160518	0300	4.6	25	E4	8.6	36	---	---	0
Site 3	20160519	0300	4.6	25	<50	8.6	36	---	---	0
Site 3, May 2016, 4-day average			4.4	25	E4	---	---	7.5	33	0
Site 3**	20160602	1200	---**	25	<50**	---	36	---	---	0
Site 3	20160712	0300	5.1	25	E4	9.4	36	---	---	0
Site 3	20160713	0300	4.9	25	E6	9.1	36	---	---	0
Site 3	20160714	0300	4.8	25	E7	8.9	36	---	---	0
Site 3	20160715	0300	4.4	25	E5	8.3	36	---	---	0
Site 3, July 2016, 4-day average			4.8	25	E6	---	---	8.0	33	0
Site 4 east of the Main Post										
Site 4	20151206	0100	11	25	E3	18	36	---	---	0
Site 4	20151207	0400	11	25	E3	18	36	---	---	0
Site 4	20151208	0600	11	25	<50	18	36	---	---	0
Site 4	20151209	0400	10	25	<50	17	36	---	---	0
Site 4, Dec. 2015, 4-day average			11	25	E4	---	---	16	33	0

Table 9. Calculated aquatic-life criteria for zinc in water from three sites located near the Peason Ridge training area and two sites located near the Main Post, Fort Polk Military Reservation, December 2015–July 2016.—Continued

[Dates are given in yyyyymmdd format; EPA, U.S. Environmental Protection Agency; CMC, aquatic-life criterion maximum concentration; CCC, aquatic-life criterion continuous concentration; mg/L, milligram per liter; LDEQ, Louisiana Department of Environmental Quality; µg/L, microgram per liter; E, estimated value, <, less than; ---, not applicable or no data; Bold text highlights exceedances; Hardness values were calculated by multiplying the sum of the calcium and magnesium concentrations, in milliequivalents per liter, by 50 (Hem, 1985). A concentration of 25 mg/L was used to calculate the LDEQ hardness-based aquatic-life criteria for selected trace elements when hardness values were less than 25 mg/L in the streams (LDEQ, 2015)]

Site (fig. 1)	Date	Time	Hardness used to calculate the EPA CMC and CCC, in mg/L (00900*)	Hardness used to calcu- late the LDEQ CMC and CCC, in mg/L	Zinc, total, in µg/L (01092*)	Zinc, hardness- based EPA CMC (calc), in µg/L	Zinc, hardness- based LDEQ acute (calc), in µg/L	Zinc, hardness- based EPA CCC (calc), in µg/L	Zinc, hardness- based LDEQ chronic (calc), in µg/L	Number of exceedances
Site 4 east of the Main Post—Continued										
Site 4	20160523	1000	14	25	<50	22	36	---	---	0
Site 4	20160524	0100	11	25	<50	18	36	---	---	0
Site 4	20160525	0100	10	25	<50	17	36	---	---	0
Site 4	20160526	0100	10	25	<50	17	36	---	---	0
Site 4, May 2016, 4-day average			11	25	<50	---	---	16	33	0
Site 4**	20160602	1500	7.3**	25	E2**	13	36	---	---	0
Site 4	20160718	0100	11	25	E6	18	36	---	---	0
Site 4	20160719	0100	11	25	E7	18	36	---	---	0
Site 4	20160720	0100	12	25	E7	19	36	---	---	0
Site 4	20160721	0100	11	25	E6	18	36	---	---	0
Site 4, July 2016, 4-day average			11	25	E6	---	---	16	33	0
Site 5 west of the Main Post										
Site 5	20151206	0100	4.3	25	E2	8.1	36	---	---	0
Site 5	20151207	0100	7.2	25	E3	13	36	---	---	0
Site 5	20151208	0100	4.1	25	E2	7.8	36	---	---	0
Site 5	20151209	0400	4.0	25	E3	7.7	36	---	---	0
Site 5, Dec. 2015, 4-day average			4.9	25	E2	---	---	8.2	33	0
Site 5	20160523	1300	4.3	25	E4	8.1	36	---	---	0
Site 5	20160524	0200	3.9	25	<50	7.5	36	---	---	0
Site 5	20160525	0200	4.3	25	<50	8.1	36	---	---	0
Site 5	20160526	0200	4.2	25	<50	8.0	36	---	---	0
Site 5, May 2016, 4-day average			4.2	25	E5	---	---	7.2	33	0
Site 5**	20160602	1400	8.0**	25	E8**	14	36	---	---	0
Site 5	20160718	0200	4.7	25	E7	8.8	36	---	---	0
Site 5	20160719	0200	5.0	25	E7	9.2	36	---	---	0
Site 5	20160720	0200	4.7	25	E6	8.8	36	---	---	0
Site 5	20160721	0200	4.7	25	E7	8.8	36	---	---	0
Site 5, July 2016, 4-day average			4.8	25	E7	---	---	8.1	33	0

*USGS parameter code; refer to appendix 1.

**Sampled during high stage (spate).

Zinc was detected in 17 of the 26 (65 percent) stream-water samples collected at the 2 sites near the Main Post, with detected concentrations ranging from E2 to E8 $\mu\text{g/L}$ (table 9). For sites 4 and 5, the EPA CMC ranged from 7.5 to 22 $\mu\text{g/L}$, and the LDEQ acute criteria was 36 $\mu\text{g/L}$. No concentrations of zinc exceeded the EPA and LDEQ acute aquatic-life criteria at the 2 sites near the Main Post. For sites 4 and 5, the six 4-day average concentrations ranged from not detected (<50 $\mu\text{g/L}$) to E7 $\mu\text{g/L}$. The EPA CCC for lead ranged from 7.2 to 16 $\mu\text{g/L}$, and the LDEQ chronic criteria was 33 $\mu\text{g/L}$. No concentrations of zinc exceeded the EPA and LDEQ chronic aquatic-life criteria at the 2 sites near the Main Post.

Summary and Conclusions

The primary purpose of this report was to calculate aquatic-life criteria for cadmium, copper, lead, and zinc in selected streams near the U.S. Army Joint Readiness Training Center (JRTC) and Fort Polk Military Reservation. The acute aquatic-life criteria used for this study are as follows: the U.S. Environmental Protection Agency (EPA) hardness-based aquatic-life criterion maximum concentration (CMC) for cadmium, lead, and zinc; the historical EPA hardness-based CMC and the biotic-ligand-model-(BLM)-based CMC for copper; and the Louisiana Department of Environmental Quality (LDEQ) hardness-based acute aquatic-life criteria for cadmium, copper, lead, and zinc. The chronic aquatic-life criteria used for this study are as follows: the EPA hardness-based aquatic-life criterion continuous concentration (CCC) for cadmium, lead, and zinc; the historical EPA hardness-based CCC and the EPA BLM-based CCC for copper; and the LDEQ hardness-based chronic aquatic-life criteria for cadmium, copper, lead, and zinc.

Copper was the most detected (82 percent) trace element, followed by zinc (76 percent), lead (69 percent), and cadmium (2.9 percent), in stream-water samples collected near Peason Ridge and the Main Post. Concentrations of copper exceeded the EPA and LDEQ acute criteria in 41 percent of the daily samples, followed by cadmium and lead (2.9 percent), and zinc (1.5 percent). Lead concentrations exceeded the EPA and LDEQ chronic criteria in 80 percent of the 4-day average concentrations, followed by copper (53 percent), and cadmium and zinc (6.7 percent).

The presence of cadmium, copper, lead, and zinc at concentrations above the acute or chronic aquatic-life criteria in relatively pristine streams near the Reservation indicated that these low-ionic strength waters are susceptible to elevated trace elements concentrations because hardness values are very small. Because trace element concentrations for acute and chronic aquatic-life criteria were small, typically less than 5 $\mu\text{g/L}$, part-per-billion protocols were carefully followed for field collection and sample handling procedures, and laboratory method reporting limits were carefully considered. Future studies involving common trace elements could be improved by including measurements of temperature, percentage humic

acid, and alkalinity, when possible, along with dissolved organic carbon, cations, and selected trace element concentrations to satisfy all parameter requirements for the EPA BLM-based calculation of aquatic-life criteria for copper. The documentation of cadmium, copper, lead, and zinc concentrations and other water-quality characteristics and the calculated acute and chronic aquatic-life criteria in relatively undisturbed streams near the Reservation can provide water-resource managers a baseline with which to compare water quality in streams within the boundaries of the Reservation.

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Appendixes 1–3

Appendix 1. Properties and constituents analyzed in samples collected from three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.

[USGS, U.S. Geological Survey; WG, groundwater; WS, surface water; SB, streambed sediment; SO, soil; NTRU, nephelometric turbidity ratio unit; mg/L, milligram per liter; nm, nanometers; mg/kg, milligram per kilogram. For additional information, see <https://nwis.waterdata.usgs.gov/nwis/qwdata> and Heal and Tollett (2020)]

USGS parameter code	USGS medium code	Number of samples near Peason Ridge (sites 1–3)	Number of samples near Main Post (sites 4–5)	Type of property or constituent	Property or constituent description
00025	WS	36	22	Field properties	Barometric pressure, millimeters of mercury
81903	WS	36	24	Field properties	Depth to bottom at sample location, feet
00300	WS	36	22	Field properties	Dissolved oxygen, water, unfiltered, mg/L
00301	WS	36	22	Field properties	Dissolved oxygen, water, unfiltered, percent of saturation
63002	WS	27	14	Field properties	Oxidation reduction potential, relative to the standard hydrogen electrode (SHE), millivolts
00400	WS	36	23	Field properties	pH, water, unfiltered, field, standard units
00003	WS	36	24	Field properties	Sampling depth, feet
00095	WS	36	24	Field properties	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00020	WS	42	26	Field properties	Temperature, air, degrees Celsius
00010	WS	36	23	Field properties	Temperature, water, degrees Celsius
63676	WS	38	25	Field properties	Turbidity, water, unfiltered, broad band light source (400–680 nm), ratiometric correction, NTRU
00025	WG	9	6	Field properties	Barometric pressure, millimeters of mercury
72016	WG	6	6	Field properties	Depth to bottom of sample interval, feet below land surface datum
72015	WG	6	6	Field properties	Depth to top of sample interval, feet below land surface datum
30210	WG	6	6	Field properties	Depth to water level, below land surface datum, meters
72019	WG	6	6	Field properties	Depth to water level, feet below land surface
00300	WG	9	6	Field properties	Dissolved oxygen, water, unfiltered, mg/L
00301	WG	9	6	Field properties	Dissolved oxygen, water, unfiltered, percent of saturation
00059	WG	7	6	Field properties	Flow rate, instantaneous, gallons per minute
63002	WG	2		Field properties	Oxidation reduction potential, relative to the standard hydrogen electrode, millivolts
00400	WG	9	6	Field properties	pH, water, unfiltered, field, standard units
00003	WG	6	6	Field properties	Sampling depth, feet
00095	WG	9	6	Field properties	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00020	WG	9	6	Field properties	Temperature, air, degrees Celsius
00010	WG	9	6	Field properties	Temperature, water, degrees Celsius
63676	WG	9	6	Field properties	Turbidity, water, unfiltered, broad band light source (400–680 nm), ratiometric correction, NTRU
00025	SB	7	4	Field properties	Barometric pressure, millimeters of mercury
00300	SB	8	4	Field properties	Dissolved oxygen, water, unfiltered, mg/L
00301	SB	8	4	Field properties	Dissolved oxygen, water, unfiltered, percent of saturation
63002	SB	7	4	Field properties	Oxidation reduction potential, relative to the standard hydrogen electrode (SHE), millivolts
00400	SB	8	4	Field properties	pH, water, unfiltered, field, standard units

Appendix 1. Properties and constituents analyzed in samples collected from three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[USGS, U.S. Geological Survey; WG, groundwater; WS, surface water; SB, streambed sediment; SO, soil; NTRU, nephelometric turbidity ratio unit; mg/L, milligram per liter; nm, nanometers; mg/kg, milligram per kilogram. For additional information, see <https://nwis.waterdata.usgs.gov/nwis/qwdata> and Heal and Tollett (2020)]

USGS parameter code	USGS medium code	Number of samples near Peason Ridge (sites 1–3)	Number of samples near Main Post (sites 4–5)	Type of property or constituent	Property or constituent description
00095	SB	8	4	Field properties	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00020	SB	9	6	Field properties	Temperature, air, degrees Celsius
00010	SB	8	4	Field properties	Temperature, water, degrees Celsius
63676	SB	4	2	Field properties	Turbidity, water, unfiltered, broad band light source (400–680 nm), ratiometric correction, NTRU
00020	SO	9	6	Field properties	Temperature, air, degrees Celsius
29802	WS	10	24	Field properties	Alkalinity, water, filtered, Gran titration, field, mg/L as calcium carbonate
39086	WS	10	24	Field properties	Alkalinity, water, filtered, inflection-point method, field, mg/L as calcium carbonate
63786	WS	10	24	Field properties	Bicarbonate, water, filtered, Gran titration, field, mg/L
00453	WS	10	24	Field properties	Bicarbonate, water, filtered, inflection-point method, field, mg/L
00900	WS	42	26	Major inorganic ions	Hardness, water, milligrams per liter as calcium carbonate (calculated)
82032	WS	42	26	Major inorganic ions	Calcium, water, unfiltered, total, mg/L
00405	WS	13	23	Major inorganic ions	Carbon dioxide, water, unfiltered, mg/L
99220	WS	42	26	Major inorganic ions	Chloride, water, unfiltered, mg/L
00951	WS	42	26	Major inorganic ions	Fluoride, water, unfiltered, mg/L
82034	WS	42	26	Major inorganic ions	Potassium, water, unfiltered, total, mg/L
82035	WS	42	26	Major inorganic ions	Sodium, water, unfiltered, total, mg/L
00946	WS	42	26	Major inorganic ions	Sulfate, water, unfiltered, mg/L
29802	WG	2	6	Field properties	Alkalinity, water, filtered, Gran titration, field, mg/L as calcium carbonate
39086	WG	7	6	Field properties	Alkalinity, water, filtered, inflection-point method, field, mg/L as calcium carbonate
63786	WG	2	6	Field properties	Bicarbonate, water, filtered, Gran titration, field, mg/L
00453	WG	7	6	Field properties	Bicarbonate, water, filtered, inflection-point method, field, mg/L
00900	WG	9	6	Major Inorganic Ions	Hardness, water, milligrams per liter as calcium carbonate (calculated)
91051	WG	9	6	Major Inorganic Ions	Calcium, water, filtered, micrograms per liter
00405	WG	7	6	Major Inorganic Ions	Carbon dioxide, water, unfiltered, mg/L
00940	WG	9	6	Major Inorganic Ions	Chloride, water, filtered, mg/L
00950	WG	9	6	Major Inorganic Ions	Fluoride, water, filtered, mg/L
91054	WG	9	6	Major Inorganic Ions	Potassium, water, filtered, micrograms per liter
91053	WG	9	6	Major Inorganic Ions	Sodium, water, filtered, micrograms per liter
00945	WG	9	6	Major Inorganic Ions	Sulfate, water, filtered, mg/L
00917	SB	9	6	Major Inorganic Ions	Calcium, bed sediment, recoverable, dry weight, mg/kg
00938	SB	9	6	Major Inorganic Ions	Potassium, bed sediment, recoverable, dry weight, mg/kg

34 Concentrations of Cadmium, Copper, Lead, and Zinc in Streams, Fort Polk Military Reservation

Appendix 1. Properties and constituents analyzed in samples collected from three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[USGS, U.S. Geological Survey; WG, groundwater; WS, surface water; SB, streambed sediment; SO, soil; NTRU, nephelometric turbidity ratio unit; mg/L, milligram per liter; nm, nanometers; mg/kg, milligram per kilogram. For additional information, see <https://nwis.waterdata.usgs.gov/nwis/qwdata> and Heal and Tollett (2020)]

USGS parameter code	USGS medium code	Number of samples near Peason Ridge (sites 1–3)	Number of samples near Main Post (sites 4–5)	Type of property or constituent	Property or constituent description
00934	SB	9	6	Major Inorganic Ions	Sodium, bed sediment, recoverable, dry weight, mg/kg
29828	SO	9	6	Major Inorganic Ions	Calcium, soil, recoverable, dry weight, mg/kg
52143	SO	9	6	Major Inorganic Ions	Potassium, soil, recoverable, dry weight, mg/kg
29851	SO	9	6	Major Inorganic Ions	Sodium, soil, recoverable, dry weight, mg/kg
01097	WS	42	26	Trace elements	Antimony, water, unfiltered, micrograms per liter
00978	WS	42	26	Trace elements	Arsenic, water, unfiltered, recoverable, micrograms per liter
63689	WS	42	26	Trace elements	Bromide, water, unfiltered, mg/L
01027	WS	42	26	Trace elements	Cadmium, water, unfiltered, micrograms per liter
01042	WS	42	26	Trace elements	Copper, water, unfiltered, recoverable, micrograms per liter
01045	WS	42	26	Trace elements	Iron, water, unfiltered, recoverable, micrograms per liter
01051	WS	42	26	Trace elements	Lead, water, unfiltered, recoverable, micrograms per liter
82033	WS	42	26	Trace elements	Magnesium, water, unfiltered, total, micrograms per liter
01055	WS	42	26	Trace elements	Manganese, water, unfiltered, recoverable, micrograms per liter
71900	WS	42	26	Trace elements	Mercury, water, unfiltered, recoverable, micrograms per liter
01092	WS	42	26	Trace elements	Zinc, water, unfiltered, recoverable, micrograms per liter
01095	WG	9	6	Trace elements	Antimony, water, filtered, micrograms per liter
01000	WG	9	6	Trace elements	Arsenic, water, filtered, micrograms per liter
71870	WG	9	6	Trace elements	Bromide, water, filtered, mg/L
01025	WG	9	6	Trace elements	Cadmium, water, filtered, micrograms per liter
01040	WG	9	6	Trace elements	Copper, water, filtered, micrograms per liter
01046	WG	9	6	Trace elements	Iron, water, filtered, micrograms per liter
01049	WG	9	6	Trace elements	Lead, water, filtered, micrograms per liter
91052	WG	9	6	Trace elements	Magnesium, water, filtered, micrograms per liter
01056	WG	9	6	Trace elements	Manganese, water, filtered, micrograms per liter
71890	WG	9	6	Trace elements	Mercury, water, filtered, micrograms per liter
01090	WG	9	6	Trace elements	Zinc, water, filtered, micrograms per liter
65212	SB	9	6	Trace elements	Antimony, bed sediment, recoverable, dry weight, mg/kg
64847	SB	9	6	Trace elements	Arsenic, bed sediment, recoverable, dry weight, mg/kg
01028	SB	9	6	Trace elements	Cadmium, bed sediment, recoverable, dry weight, mg/kg
01043	SB	9	6	Trace elements	Copper, bed sediment, recoverable, dry weight, mg/kg
64906	SB	9	6	Trace elements	Iron, bed sediment, recoverable, dry weight, mg/kg
01052	SB	9	6	Trace elements	Lead, bed sediment, recoverable, dry weight, mg/kg
00924	SB	9	6	Trace elements	Magnesium, bed sediment, recoverable, dry weight, mg/kg
01053	SB	9	6	Trace elements	Manganese, bed sediment, recoverable, dry weight, mg/kg
71921	SB	9	6	Trace elements	Mercury, bed sediment, recoverable, dry weight, mg/kg
01093	SB	9	6	Trace elements	Zinc, bed sediment, recoverable, dry weight, mg/kg
29817	SO	9	6	Trace elements	Antimony, soil, recoverable, dry weight, mg/kg

Appendix 1. Properties and constituents analyzed in samples collected from three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[USGS, U.S. Geological Survey; WG, groundwater; WS, surface water; SB, streambed sediment; SO, soil; NTRU, nephelometric turbidity ratio unit; mg/L, milligram per liter; nm, nanometers; mg/kg, milligram per kilogram. For additional information, see <https://nwis.waterdata.usgs.gov/nwis/qwdata> and Heal and Tollett (2020)]

USGS parameter code	USGS medium code	Number of samples near Peason Ridge (sites 1–3)	Number of samples near Main Post (sites 4–5)	Type of property or constituent	Property or constituent description
29819	SO	9	6	Trace elements	Arsenic, soil, recoverable, dry weight, mg/kg
29827	SO	9	6	Trace elements	Cadmium, soil, recoverable, dry weight, mg/kg
29833	SO	9	6	Trace elements	Copper, soil, recoverable, dry weight, mg/kg
29835	SO	9	6	Trace elements	Iron, soil, recoverable, dry weight, mg/kg
29837	SO	9	6	Trace elements	Lead, soil, recoverable, dry weight, mg/kg
29838	SO	9	6	Trace elements	Magnesium, soil, recoverable, dry weight, mg/kg
29840	SO	9	6	Trace elements	Manganese, soil, recoverable, dry weight, mg/kg
29842	SO	9	6	Trace elements	Mercury, soil, recoverable, dry weight, mg/kg
29856	SO	9	6	Trace elements	Zinc, soil, recoverable, dry weight, mg/kg
00681	WS	42	26	Dissolved organic carbon	Organic carbon, water, filtered, mg/L
00681	WG	9	6	Dissolved organic carbon	Organic carbon, water, filtered, mg/L
00620	WS	42	26	Nutrients	Nitrate, water, unfiltered, mg/L as nitrogen
00615	WS	42	26	Nutrients	Nitrite, water, unfiltered, mg/L as nitrogen
70507	WS	42	26	Nutrients	Orthophosphate, water, unfiltered, mg/L as phosphorus
00650	WS	42	26	Nutrients	Phosphate, water, unfiltered, mg/L
00618	WG	9	6	Nutrients	Nitrate, water, filtered, mg/L as nitrogen
00613	WG	9	6	Nutrients	Nitrite, water, filtered, mg/L as nitrogen
00660	WG	9	3	Nutrients	Orthophosphate, water, filtered, mg/L
00671	WG	9	3	Nutrients	Orthophosphate, water, filtered, mg/L as phosphorus
64178	SB	9	6	Organic carbon	Loss on ignition, bed sediment, percent
68923	SO	9	6	Organic carbon	Loss on ignition, soil, dry, heated to 450 degrees Celsius, percent
91156	SB	9	6	Moisture content	Moisture content, bed sediment, dry weight, percent
46311	SO	9	6	Moisture content	Moisture content, soil, dry weight, percent

36 Concentrations of Cadmium, Copper, Lead, and Zinc in Streams, Fort Polk Military Reservation

Appendix 2. Guidelines, criteria, and standards used as reference for analysis of stream-water-quality samples collected from three sites near the Peason Ridge training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016 (EPA, 2002, 2009, 2016, 2019b; LDEQ, 2015).

[FW, freshwater; EPA, U.S. Environmental Protection Agency; CMC, criterion maximum concentration; CCC, criterion continuous concentration; LDEQ, Louisiana Department of Environmental Quality; S.U., standard unit; NRTU, nephelometric turbidity ratio unit; ---, not applicable]

Property or constituent	Surface water			
	EPA aquatic-life criteria (FW)		LDEQ aquatic-life criteria	
	CMC	CCC	Acute	Chronic
Field properties				
Dissolved oxygen	---	---	---	---
pH, field, in S.U.	---	6.5–9	---	---
Specific conductance	---	---	---	---
Temperature	---	---	---	---
Turbidity, in NRTU	---	---	---	---
Major inorganic ions, in milligrams per liter				
Total dissolved solids	---	---	---	---
Alkalinity	---	20.0	---	---
Bicarbonate	---	---	---	---
Calcium	---	---	---	---
Chloride	860	230	---	---
Fluoride	---	---	---	---
Hardness	---	---	---	---
Potassium	---	---	---	---
Sodium	---	---	---	---
Sulfate	---	---	---	---
Trace elements, in micrograms per liter (water)				
Antimony	---	---	---	---
Arsenic	340*	150*	340*	150*
Bromide	---	---	---	---
Cadmium	0.52**	0.10**	7.05**	0.38**
Copper	3.8**	2.9**	5.2**	3.9**
Iron	---	1,000	---	---
Lead	14**	0.54**	14**	0.54**
Magnesium	---	---	---	---
Manganese	---	---	---	---
Mercury	1.4	0.77	2.04	0.012
Zinc	37	37	36	33

*Threshold or guideline is for dissolved concentrations.

**The EPA CMC, EPA CCC, and LDEQ acute and chronic aquatic-life criteria are shown for a fixed hardness of 25 mg/L. See [tables 6–9](#) for calculations by sample.

Appendix 3. Values and concentrations used to calculate aquatic-life criteria based on the biotic ligand model for copper (U.S. Environmental Protection Agency, 2019b) for three sites located near the Peason training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.

[Dates are given in yyyyymmdd format; °C, degrees Celsius; Temp, temperature; DOC, dissolved organic carbon; %, percent; BLM, EPA Biotic Ligand Model; CMC, Aquatic-Life Criterion Maximum Concentration; CCC, Aquatic-Life Criterion Continuous Concentration; mg/L, milligram per liter; µg/L, microgram per liter; ---, not applicable or no data]

Site number	Date	Temp (°C)	pH	Copper, in µg/L	DOC, in mg/L	Humic acid, in %	Calcium, in mg/L	Magnesium, in mg/L	Sodium, in mg/L	Potassium, in mg/L	Sulfate, in mg/L	Chloride, in mg/L	Alkalinity, in mg/L	Sulfide, in mg/L	Copper BLM CMC, in µg/L	Copper BLM CCC, in µg/L
Site 1 east of the Peason Ridge training area																
Site 1	20151205	11.3	6.2	0.66	3.2	10*	1.80	0.660	3.90	1.10	4.50	3.00	2.5	1.00E-10*	1.2	---
Site 1	20151206	11.9	6.4	0.54	2.8	10*	1.60	0.630	3.60	1.10	5.00	4.20	0.2	1.00E-10*	1.8	---
Site 1	20151207	11.2	6.1	0.64	2.8	10*	1.60	0.600	3.50	1.00	5.00	3.20	2.8*	1.00E-10*	0.80	---
Site 1	20151208	13.4	6.1	0.44	3.2	10*	1.60	0.610	3.60	1.30	4.90	5.90	0.2	1.00E-10*	0.92	---
Site 1, Dec. 2015, 4-day average		12.0	6.2	0.57	3.0	10*	1.65	0.625	3.65	1.13	4.85	4.08	1.0	1.00E-10*	---	0.71
Site 1***	20160309***	19.0*	6.4*	2.20	11	10*	1.90	1.000	2.00	1.50	4.30	2.00	2.8*	1.00E-10*	7.8	---
Site 1	20160516	19.2	6.4	0.10**	2.6	10*	1.70	0.560	3.80	0.85	3.50	3.00	2.8*	1.00E-10*	1.7	---
Site 1	20160517	19.5	6.4	0.87	3.2	10*	3.90	1.300	5.20	0.93	3.50	3.20	2.8*	1.00E-10*	2.0	---
Site 1	20160518	19.6	6.4	0.28	3.2	10*	1.50	0.530	3.70	0.81	3.10	3.00	2.8*	1.00E-10*	2.1	---
Site 1	20160519	18.1	6.5	0.10**	3.2	10*	2.70	0.850	3.80	0.87	3.50	3.10	2.8*	1.00E-10*	2.5	---
Site 1, May 2016, 4-day average		19.1	6.4	0.58	3.1	10*	2.45	0.810	4.13	0.87	3.40	3.08	2.8*	1.00E-10*	---	1.2
Site 1***	20160602***	19.0*	6.4*	1.40	17	10*	1.50	0.570	2.20	0.88	3.60	1.90	2.8*	1.00E-10*	16	---
Site 1	20160712	23.9	6.7	1.90	2.6	10*	1.70	0.490	3.60	0.90	3.30	3.00	2.8*	1.00E-10*	3.3	---
Site 1	20160713	24.4	6.5	0.57	2.6	10*	1.50	0.520	4.00	1.00	3.70	3.10	2.8*	1.00E-10*	2.2	---
Site 1	20160714	26.0	6.8	1.30	2.8	10*	1.60	0.550	4.30	1.10	3.50	3.10	2.8*	1.00E-10*	4.3	---
Site 1	20160715	25.3	6.7	1.90	3.1	10*	1.60	0.550	4.20	1.10	3.50	3.10	2.8*	1.00E-10*	4.0	---
Site 1, July 2016, 4-day average		24.9	6.7	1.42	2.8	10*	1.60	0.528	4.03	1.03	3.50	3.08	2.8*	1.00E-10*	---	2.2
Site 2 east of the Peason Ridge training area																
Site 2	20151206	8.2	6.2	0.96	2.9	10*	1.40	0.63	3.00	0.95	4.30	2.90	2.4	1.00E-10*	1.1	---
Site 2	20151208	8.6	6.4	0.88	3.6	10*	1.50	0.61	3.20	0.94	4.50	3.00	2.8*	1.00E-10*	2.3	---
Site 2	20151208	12.2	6.1	0.48	3.4	10*	1.40	0.58	3.10	1.10	4.60	5.30	0.2	1.00E-10*	0.99	---
Site 2	20151209	13.3	6.1	0.77	3.6	10*	1.20	0.66	3.30	1.10	39.00	19.00	2.8*	1.00E-10*	0.95	---

Appendix 3. Values and concentrations used to calculate aquatic-life criteria based on the biotic ligand model for copper (U.S. Environmental Protection Agency, 2019b) for three sites located near the Peason training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[Dates are given in yyyyymmdd format; °C, degrees Celsius; Temp, temperature; DOC, dissolved organic carbon; %, percent; BLM, EPA Biotic Ligand Model; CMC, Aquatic-Life Criterion Maximum Concentration; CCC, Aquatic-Life Criterion Continuous Concentration; mg/L, milligram per liter; µg/L, microgram per liter; ---, not applicable or no data]

Site number	Date	Temp (°C)	pH	Copper, in µg/L	DOC, in mg/L	Humic acid, in %	Calcium, in mg/L	Magnesium, in mg/L	Sodium, in mg/L	Potassium, in mg/L	Sulfate, in mg/L	Chloride, in mg/L	Alkalinity, in mg/L	Sulfide, in mg/L	Copper BLM CMC, in µg/L	Copper BLM CCC, in µg/L
Site 2 east of the Peason Ridge training area—Continued																
Site 2, Dec. 2015, 4-day average		10.6	6.2	0.77	3.4	10*	1.4	0.6	3.2	1.0	13.1	7.6	1.3	1.00E-10*	---	0.78
Site 2***	20160309***	19.0*	6.4*	4.20	9.9	10*	2.80	1.30	2.20	1.60	3.30	2.40	2.8*	1.00E-10*	6.6	---
Site 2	20160516	20.7	6.4	0.54	3.3	10*	1.50	0.58	3.40	0.77	3.60	3.10	2.8*	1.00E-10*	2.1	---
Site 2	20160517	19.0*	6.4	1.00	5.0	10*	1.50	0.58	3.40	0.83	3.40	3.20	2.8*	1.00E-10*	3.4	---
Site 2	20160518	20.2	6.4	0.84	3.4	10*	3.70	1.60	3.90	0.81	3.50	3.20	2.8*	1.00E-10*	2.1	---
Site 2	20160519	17.8	6.5	0.10	3.5	10*	1.60	0.62	3.70	0.85	3.60	3.30	2.8*	1.00E-10*	2.9	---
Site 2, May 2016, 4-day average		19.6	6.4	0.62	3.8	10*	2.1	0.8	3.6	0.8	3.5	3.2	2.8*	1.00E-10*	---	1.5
Site 2***	20160602***	19.0*	6.4*	0.88	11	10*	1.10	0.58	2.70	0.80	2.40	2.00	2.8*	1.00E-10*	9.2	---
Site 2	20160712	26.0	6.7	1.30	5.4	10*	2.10	0.68	4.20	1.00	5.20	3.80	4.7	1.00E-10*	7.0	---
Site 2	20160713	28.2	6.5	1.00	4.0	10*	2.20	0.77	4.90	1.20	5.40	3.90	5.1	1.00E-10*	3.3	---
Site 2	20160714	28.5	6.8	4.20	4.1	10*	2.10	0.77	4.80	1.20	5.80	3.80	2.8*	1.00E-10*	6.3	---
Site 2	20160715	27.2	6.7	1.40	4.7	10*	2.20	0.79	4.80	1.20	5.80	3.90	2.8*	1.00E-10*	6.0	---
Site 2, July 2016, 4-day average		27.5	6.7	1.98	4.6	10*	2.2	0.8	4.7	1.2	5.6	3.9	4.9	1.00E-10*	---	3.6
Site 3 west of the Peason Ridge training area																
Site 3	20151205	12.5	6.5	0.68	2.30	10*	1.10	0.56	2.70	1.20	2.20	3.50	2.7	1.00E-10*	1.9	---
Site 3	20151208	12.4	5.8	0.94	2.20	10*	1.00	0.56	2.70	1.20	2.60	3.40	3.3	1.00E-10*	0.28	---
Site 3	20151209	14.8	5.8	0.10**	2.10	10*	0.99	0.55	2.70	1.30	2.40	3.80	3.3	1.00E-10*	0.27	---
Site 3	20151210	14.8	5.8	0.88	2.40	10*	0.99	0.61	3.00	1.30	3.10	3.80	2.8*	1.00E-10*	0.31	---
Site 3, Dec. 2015, 4-day average		13.6	6.0	0.83	2.3	10*	1.0	0.6	2.8	1.3	2.6	3.6	3.1	1.00E-10*	---	0.32
Site 3***	20160309***	19.0*	5.9*	2.30	14.00	10*	2.30	2.20	7.70	1.20	1.60	1.70	2.8*	1.00E-10*	2.8	---
Site 3	20160516	18.8	5.8	0.10**	2.40	10*	1.10	0.55	2.90	0.90	1.60	3.80	2.8*	1.00E-10*	0.31	---
Site 3	20160517	19.6	5.9	0.34	3.20	10*	0.94	0.50	2.60	0.84	1.50	4.00	2.8*	1.00E-10*	0.56	---

Appendix 3. Values and concentrations used to calculate aquatic-life criteria based on the biotic ligand model for copper (U.S. Environmental Protection Agency, 2019b) for three sites located near the Peason training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[Dates are given in yyyyymmdd format; °C, degrees Celsius; Temp, temperature; DOC, dissolved organic carbon; %, percent; BLM, EPA Biotic Ligand Model; CMC, Aquatic-Life Criterion Maximum Concentration; CCC, Aquatic-Life Criterion Continuous Concentration; mg/L, milligram per liter; µg/L, microgram per liter; ---, not applicable or no data]

Site number	Date	Temp (°C)	pH	Copper, in µg/L	DOC, in mg/L	Humic acid, in %	Calcium, in mg/L	Magnesium, in mg/L	Sodium, in mg/L	Potassium, in mg/L	Sulfate, in mg/L	Chloride, in mg/L	Alkalinity, in mg/L	Sulfide, in mg/L	Copper BLM CMC, in µg/L	Copper BLM CCC, in µg/L
Site 3 west of the Peason Ridge training area—Continued																
Site 3	20160518	19.1	5.9	0.26	2.80	10*	1.00	0.51	2.90	0.91	1.50	3.80	2.8*	1.00E-10*	0.48	---
Site 3	20160519	18.3	5.9	0.10**	2.50	10*	0.97	0.54	2.90	0.95	1.50	3.80	2.8*	1.00E-10*	0.43	---
Site 3, May 2016, 4-day average		19.0	5.9	0.30	2.7	10*	1.0	0.5	2.8	0.9	1.5	3.9	2.8*	1.00E-10*	---	0.29
Site 3***	20160602***	19.0*	5.9*	0.10**	8.70	10*	0.25*	0.07	0.29	0.12*	1.40	3.70	2.8*	1.00E-10*	11.1	---
Site 3	20160712	22.9	6.1	0.10**	2.40	10*	1.30	0.46	2.60	1.00	1.20	3.60	3.5	1.00E-10*	0.70	---
Site 3	20160713	23.0	6.0	0.81	1.80	10*	1.10	0.52	3.00	1.20	14.00	4.30	3.7	1.00E-10*	0.38	---
Site 3	20160714	22.2	5.9	0.86	1.80	10*	1.10	0.50	2.90	1.20	1.20	3.50	2.8*	1.00E-10*	0.30	---
Site 3	20160715	22.1	5.8	1.40	2.00	10*	1.00	0.47	2.80	1.20	1.20	3.60	2.8*	1.00E-10*	0.26	---
Site 3, July 2016, 4-day average		22.6	6.0	1.0	2.0	10*	1.1	0.5	2.8	1.2	4.4	3.8	3.6	1.00E-10*	---	0.27
Site 4 east of the Main Post																
Site 4	20151206	11.8	6.3	0.80	1.5	10*	2.8	0.890	5.3	1.4	0.78	3.2	17.0	1.00E-10*	0.71	---
Site 4	20151207	15.7	6.4	0.61	1.6	10*	3	0.950	5.7	1.4	0.86	5	15.0	1.00E-10*	0.98	---
Site 4	20151208	15.8	6.4	0.38	1.3	10*	2.9	0.900	5.4	1.4	0.95	4.1	12.9	1.00E-10*	0.79	---
Site 4	20151209	17.8	6.3	0.10**	1.7	10*	2.8	0.860	5.3	1.5	0.95	3.8	14.9	1.00E-10*	0.81	---
Site 4, Dec. 2015, 4-day average		15.3	6.4	0.60	1.5	10*	2.9	0.9	5.4	1.4	0.9	4.0	15.0	1.00E-10*	---	0.57
Site 4	20160523	19.1	6.6	0.42	1	10*	4	1.100	6.4	1.2	0.72	3.2	17.9	1.00E-10*	0.95	---
Site 4	20160524	19.8	6.5	0.40	1.1	10*	2.9	0.810	5.6	1.2	0.64	3.3	18.4	1.00E-10*	0.85	---
Site 4	20160525	20.4	6.5	0.10**	1.1	10*	2.8	0.810	5.8	1.1	0.66	3.2	20.0	1.00E-10*	0.85	---
Site 4	20160526	20.9	6.5	0.10**	1	10*	2.8	0.810	5.8	1.1	0.81	3.2	19.8	1.00E-10*	0.78	---
Site 4, May 2016, 4-day average		20.1	6.5	0.41	1.1	10*	3.1	0.9	5.9	1.2	0.7	3.2	19.0	1.00E-10*	---	0.53
Site 4***	20160602***	19.0*	6.5*	2.20	10	10*	1.8	0.690	2.7	1.6	0.7	1.6	17.5*	1.00E-10*	9.1	---
Site 4	20160718	21.8	6.5*	2.50	1.7	10*	2.9	0.810	6.2	1.3	0.45	3.1	20.0	1.00E-10*	1.3	---

Appendix 3. Values and concentrations used to calculate aquatic-life criteria based on the biotic ligand model for copper (U.S. Environmental Protection Agency, 2019b) for three sites located near the Peason training area and two sites near the Main Post, Fort Polk Military Reservation, 2015–2016.—Continued

[Dates are given in yyyyymmdd format; °C, degrees Celsius; Temp, temperature; DOC, dissolved organic carbon; %, percent; BLM, EPA Biotic Ligand Model; CMC, Aquatic-Life Criterion Maximum Concentration; CCC, Aquatic-Life Criterion Continuous Concentration; mg/L, milligram per liter; µg/L, microgram per liter; ---, not applicable or no data]

Site number	Date	Temp (°C)	pH	Copper, in µg/L	DOC, in mg/L	Humic acid, in %	Calcium, in mg/L	Magnesium, in mg/L	Sodium, in mg/L	Potassium, in mg/L	Sulfate, in mg/L	Chloride, in mg/L	Alkalinity, in mg/L	Sulfide, in mg/L	Copper BLM CMC, in µg/L	Copper BLM CCC, in µg/L
Site 4 east of the Main Post—Continued																
Site 4	20160719	20.9	6.6	1.80	1.8	10*	3	0.830	6.3	1.3	0.63	3.2	17.4	1.00E-10*	1.8	---
Site 4	20160720	24.1	6.9	1.50	1.4	10*	3.2	0.860	6.6	1.4	0.86	3.2	16.3	1.00E-10*	2.4	---
Site 4	20160721	21.2	6.7	1.10	1.8	10*	3.1	0.840	6.4	1.3	1.4	3.2	17.8	1.00E-10*	2.1	---
Site 4, July 2016, 4-day average		22.0	6.7	1.73	1.7	10*	3.1	0.8	6.4	1.3	0.8	3.2	17.9	1.00E-10*	---	1.26
Site 5 west of the Main Post																
Site 5	20151206	12.1	5.7	0.63	4.8	10*	0.85	0.540	2.6	0.55	0.75	4	2.0	1.00E-10*	0.54	---
Site 5	20151207	12.2*	5.8	0.63	4.1	10*	1.5	0.840	4.5	0.57	0.94	3.8	1.0	1.00E-10*	0.55	---
Site 5	20151208	12.4	5.5	0.46	4.1	10*	0.78	0.530	2.6	0.53	0.99	3.9	0.5	1.00E-10*	0.29	---
Site 5	20151209	14.2	5.5	1.30	4.1	10*	0.74	0.530	2.7	0.6	0.97	4.3	1.5	1.00E-10*	0.30	---
Site 5, Dec. 2015, 4-day average		12.9	5.6	0.76	4.3	10*	1.0	0.6	3.1	0.6	0.9	4.0	1.3	1.00E-10*	---	0.23
Site 5	20160523	20.3	5.7	0.60	4.9	10*	0.85	0.520	3.1	0.58	0.52	4.1	2.3	1.00E-10*	0.55	---
Site 5	20160524	19.9	5.7	0.53	4.5	10*	0.79	0.460	2.8	0.53	0.51	5	1.0	1.00E-10*	0.51	---
Site 5	20160525	22.0	5.6	0.10**	4.6	10*	0.85	0.520	3.1	0.57	0.49	4.5	2.6	1.00E-10*	0.41	---
Site 5	20160526	21.7	5.6	0.32	4.7	10*	0.85	0.510	3	0.58	0.5	4	2.7	1.00E-10*	0.42	---
Site 5, May 2016, 4-day average		21.0	5.7	0.48	4.7	10*	0.8	0.5	3.0	0.6	0.5	4.4	2.2	1.00E-10*	---	0.33
Site 5***	20160602***	20.0*	5.8*	1.60	14	10*	1.7	0.920	3.5	0.75	0.75	3	2.6*	1.00E-10*	2.2	---
Site 5	20160718	23.6	5.8	2.40	4	10*	1	0.530	3.3	0.83	0.76	3.8	4.0	1.00E-10*	0.56	---
Site 5	20160719	22.5	5.9	1.50	5.1	10*	1.1	0.550	3.3	0.86	0.78	3.8	3.6	1.00E-10*	0.94	---
Site 5	20160720	23.2	6.2	1.20	3.9	10*	1	0.530	3.2	0.82	0.44	3.8	3.4	1.00E-10*	1.6	---
Site 5	20160721	22.9	6.2	0.88	4.9	10*	1	0.530	3.3	0.83	0.79	3.8	2.9	1.00E-10*	2.1	---
Site 5, July 2016, 4-day average		23.1	6.0	1.50	4.5	10	1.0	0.54	3.3	0.8	0.7	3.8	3.5	1.00E-10*	---	0.68

*These concentrations were not measured; thus, the missing values were estimated based on the average concentrations for pH and alkalinity and the EPA recommended concentration for sulfide in this model.

**These concentrations were reported as not detected and were set to one-tenth of the detection limit for this model.

***Sampled during high stage (spate).

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